80286–BASED PRODUCTS

TECHNICAL REFERENCE GUIDE – VOLUME II

COMPAQ®

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VOLUME II

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Volume 2

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80286-Based Products Technical Reference Guide

First Edition (November 1985)
Second Edition (October 1986)
Third Edition (May 1987)
Option Kit #102789-001
Assembly Mnl. Vol. 1 #106484-003
Text Vol. 1 #106485-003
Binder Vol. 1 #106486-001
Owner Info. Card #106401-002
Assembly Mnl. Vol. 2 #106487-003
Text Vol. 2 #106488-003
Binder Vol. 2 #106489-001

Compaq Computer Corporation

PREFACE

This manual provides hardware and firmware (ROM) information for the COMPAQ PORTABLE 286 and COMPAQ DESKPRO 286 Personal Computers for:

- People who want to know more about the hardware in their system and general theories about how the system works.
- Technicians or engineers who need technical information to design accessories for the system.
- Programmers who need to know about the hardware (programmable devices) and firmware (ROM) for programming purposes.

HOW TO USE THIS DOCUMENT

The most important features of any computer system are:

- What kind of processor does it have?
- How much memory can it support?
- How fast is it?
- What can be added to it?

Chapter 1 introduces the COMPAQ PORTABLE 286 and COMPAQ DESKPRO 286 Personal Computers, with answers to all these questions. Everyone should read Chapter 1 first.

Chapter 2 describes the system boards for both the COMPAQ PORTABLE 286 and COMPAQ DESKPRO 286 Personal Computers.

Chapters 3 through 13 describe the system components in detail.

Chapter 14 is a BIOS Programming Guide that explains the system firmware.

Appendix A lists the system error messages.

Appendix B describes the COMPAQ Asynchronous Communication/Parallel Printer Board

The index will help you quickly find the information you need.

NOTATIONAL CONVENTIONS

Values

I/O addresses and other values are in hexadecimal notation when shown with the letter h after them. Memory addresses are always in hexadecimal and are expressed as SSSS:0000, where SSSS is a 16-bit segment and 0000 is a 16-bit offset. All other numbers are in decimal notation.

Ranges

Ranges or limits for a parameter are shown as a pair of values separated by two dots (..). For example, 4..0 includes numbers 4, 0, and every number in between (3, 2, and 1).

Signal Labels

Signal values are labelled A0, A1, A15, etc. Signal names are in upper case. Signal names with a dash (-) as a suffix indicate that that signal is negative when true, or active when low.

Bit values are labelled bit 7, bit 6, bit 0, etc.

Labels with the smallest suffixes (A0, bit 0) have the least significance or value.

Register Notation and Usage

The standard Intel naming conventions are used for the 80286 registers. AX, BX, CX, and DX are the names of the general registers when used as word-length registers (16-bit). AH, AL, BH, BL, CH, CL, DH, and DL are the names for the general registers when they are used as byte-length registers (8-bit). When addresses are handled, BX usually contains the offset. However, SI (source index) or BP (base pointer) may also be used with the ES register.

The ES register denotes the extra segment and is used exclusively for address-segment parameter passing; FL is the flag register used to return the status of some operations. Status is given as the state of one of the flags within the register: CF for carry flag, IF for interrupt flag, etc.

The shaded register-set boxes are ignored on input and are unchanged for output. An exception is that the contents of AX are not guaranteed to be preserved across all calls. Always reload the function code in AH and the parameter in AL (if any) to repeat a call. Register contents are always preserved across BIOS calls, unless the register is used to return a value.

Bit Notation

Bit fields within a byte or word are shown as a range of decimal numbers separated by two dots <..> and enclosed in angle brackets. For example, reference to the four most-significant bits in a word is made with <15..12>. The higher number, representing the most-significant bit, is on the left.

Common Abbreviations

The following abbreviations are used throughout this guide:

Abbr.	Meaning	Comment
CNTLR	Controller	
DMA	Direct Memory Access	
FRI	Flux Reversals per Inch	
INT	Interrupt	
KB	Kilobyte	1024 Bytes
MB	Megabyte	1,024,000 Bytes
ms	Millisecond	Always preceded by a number
ns	Nanosecond	Always preceded by a number
RAM	Random-Access Memory	
ROM	Read-Only Memory	
RTC	Real-Time Clock	
TPI	Tracks Per Inch	
us	Microsecond	Always preceded by a number

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Chapter 7

VIDEO DISPLAY CONTROLLER BOARDS

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Chapter 7
VIDEO DISPLAY CONTROLLER BOARDS

7.1 INTRODUCTION

The video display controller board (Figure 7-1) provides a way to display information on one of several types of CRT displays. The video display controller board is functionally identical in both the COMPAQ PORTABLE 286® and the COMPAQ DESKPRO 286® Personal Computers.

The video display controller board has the following features:

- Dual-mode displays
- Updatable Display without blanking
- Socketed character-generator ROM
- Color-graphics capabilities
- Lightpen capability
- Composite-video capability

There are three versions of the video display controller board. All three versions are functionally identical. The Video Display Controllers are shown in Figures 7-1, 7-2 and 7-3.

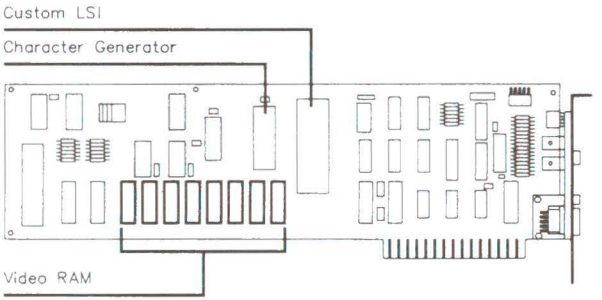


Figure 7-1. Version 1 of the Video Display Controller Board

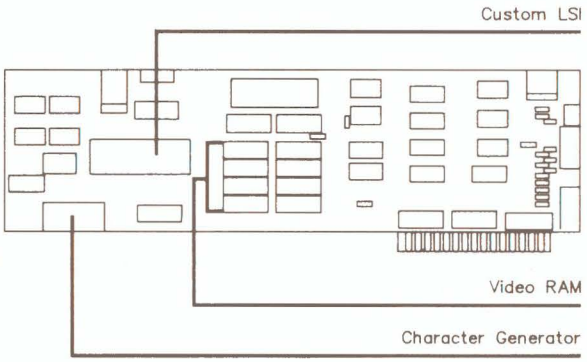


Figure 7-2. Version 2 of the Video Display Controller Board

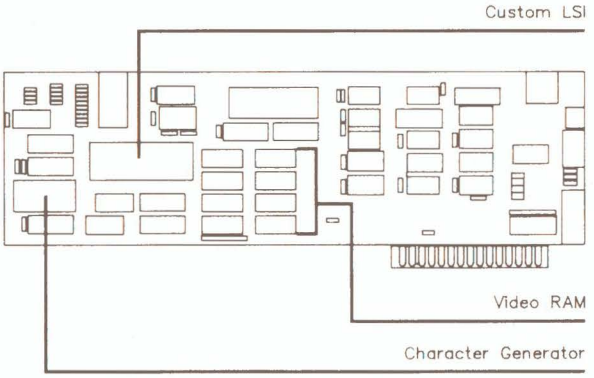


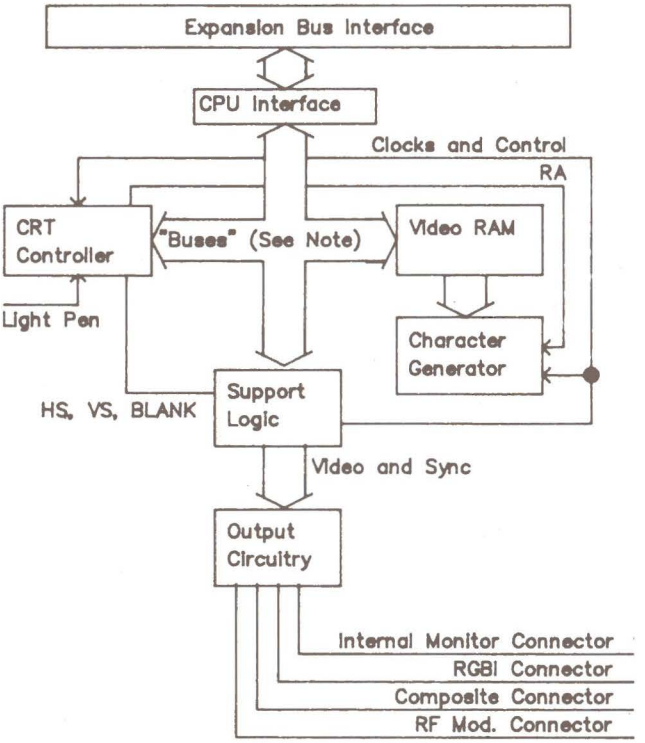
Figure 7-3. Version 3 of the Video Display Controller Board

7.2 FUNCTIONAL DESCRIPTION

The video display controller board consists of 6 major functional blocks:

- The CPU Interface
- CRT Controller
- Support Logic
- Video Memory
- Character Generator
- Output Circuitry

Figure 7-4 shows the functional block diagram of the Video Display Controller Board.



Note: "Buses" includes the address, data, control, and decode buses.

Figure 7-4. Video Display Controller Board Functional Block Diagram

The following sections briefly describe each functional block.

CPU Interface

The CPU interface consists of address decoding logic, address bus buffers, and data bus transceivers. The video display controller board uses the 8-bit bus to interface with the CPU. It does not require the full 16-bit bus expansion slot.

Address lines, together with the bus control signals, are used to decode valid I/O devices. The output lines of the decoders select the 6845, video memory, and other functions. The decoders also provide control of the data bus transceiver.

The interface circuitry allows shared access of video memory between the CPU and the 6845 by multiplexing address lines to the video memory. The CPU can access the video memory at any time without interfering with the display.

The interface circuitry also provides buffering for the reset signal and the 14.318 MHz clock.

Optional jumpers J7 and J8 select a base I/O port address of 3DXh (standard) or a base I/O port address of 3BXh. Optional jumper J9 selects a base memory address for the video memory of B8000h (standard) or B0000h.

CRT Controller

The CRT controller (6845) is an LSI device that generates the addresses and other signals that refresh the video memory. It also supplies the synchronization and blanking signals for the output circuitry.

The 6845 device contains 19 internal registers, all of which are I/O-mapped. The system BIOS programs the internal registers that control the display timing.

The 6845's lightpen register allows lightpen interactions for systems with monitors that are optically compatible (dual-mode monitors are not compatible due to their medium-persistence phosphor).

Support Logic

The support logic consists primarily of a custom LSI circuit that provides several video functions, including:

- Converting data bytes from the video memory or the character generator into the individual dots on the display (shift register or serialization).
- Controlling the application of the associated video attributes and conditions. The Mode and Color registers, and part of the Status register are part of this device.
- Generating the memory timing and other clock signals for the 6845.

The support logic selects the high- or low-scan mode according to the character-height parameter written to the 6845's internal register 09h. A value of 0Dh in register 09h selects the high-scan mode.

Video Memory

The video memory on the video display controller board consists of 16 Kbytes of dynamic RAM beginning at address B8000h and extending to BBFFFh (Figure 7-5). The video memory is dual-ported so that the CPU can access it at any time without causing visual anomalies on the CRT display.

One wait state is automatically inserted on all video memory cycles by asserting the I/O READY- line on the expansion bus. The wait state is required for synchronization purposes. The base address of video memory can be changed from B8000 (standard) to B0000 (optional Jumper J9).

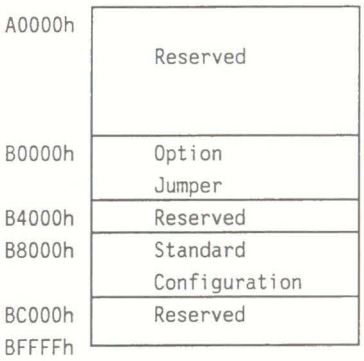


Figure 7-5. Video Memory Address Space

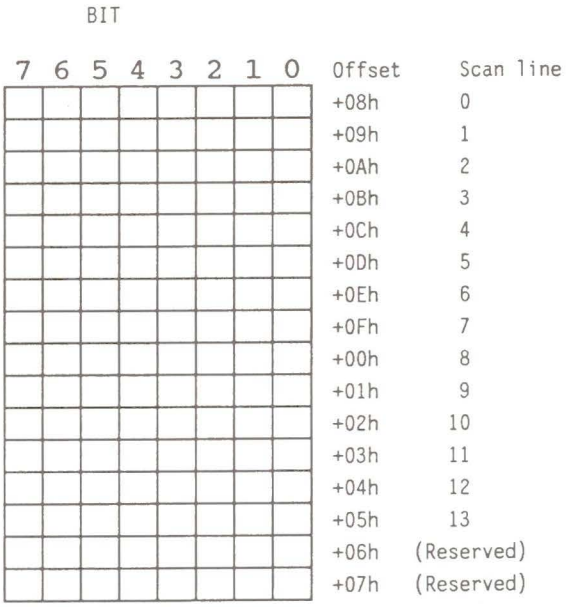
Character Generator

The character generator is an 8 Kbyte x 8 static ROM chip. Special character sets may be supported by replacing the standard ROM (socketed) with a 250 ns, 2764-type EPROM. The CPU cannot read the ROM's contents--it is accessed only by the 6845, together with video RAM.

The 8 Kbyte x 8 character generator ROM contains three character sets of 256 characters each. The first set is used for the 9 x 14 dot cell character set and takes up 4 Kbytes. From each group of 16 bytes, 14 are used to form the cell, with bytes +00h through +05h for the lower six displayed lines, and bytes +08h through +0Fh for the top eight scan lines. Scan line 0 is adjacent on the screen to scan line 13 of the character above.

The video display controller board generates a 9th horizontal dot from an 8-bit-wide ROM for 9 x 14 dot cells. It replicates bit 0 (the 8th dot) for graphics characters C0h through DFh. It places a blank dot in the 9th position for other characters. This scheme allows continuous horizontal lines and solid figures needed by certain graphics symbols.

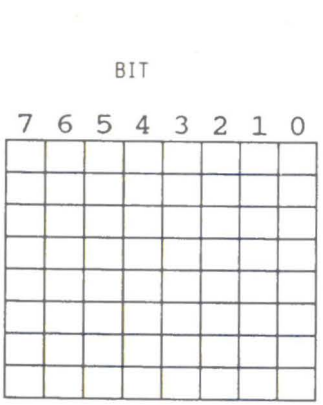
The layout of the 9 x 14 dot cell is as follows:



The second and third sets are interleaved and occupy the remaining 4 Kbytes. They provide standard and alternate 8 x 8 dot versions (selectable by Jumper J1) of an 8 x 8 dot cell character font used by both 40- and 80-column low-scan text modes. Scan line 0 is adjacent on the screen to scan line 7 of the character above.

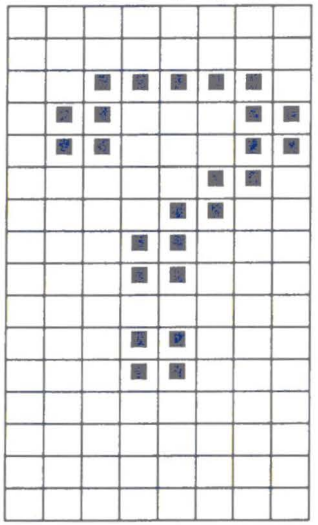
NOTE: A separate character font contained in the system ROM duplicates the first 128 standard 8 x 8 dot cells and is used by ROM BIOS routines to display text in one of the graphics display modes.

The second and third character sets in the character generator ROM have 8 x 8 dot cells and are interleaved every eight bytes. That is, the standard set begins at offset 1000h, and the alternate set begins at 1008h. The layouts are as follows:



Standard Set	Alternate Set
Offset	Offset
+00h	+08h
+01h	+09h
+02h	+0Ah
+03h	+0Bh
+04h	+0Ch
+05h	+0Dh
+06h	+0Eh
+07h	+0Fh

Example: Question mark (ASCII 3Fh) in the 9 x 14 dot cell.



Value	7	6	5	4	3	2	1	0	Address	Scan Line
00h									03F8h	0
00h									03F9h	1
3Eh			■	■	■	■	■		03FAh	2
63h		■	■				■	■	03FBh	3
63h		■	■				■	■	03FCh	4
06h						■	■		03FDh	5
0Ch					■	■			03FEh	6
18h				■	■				03FFh	7
18h				■	■				03F0h	8
00h									03F1h	9
18h				■	■				03F2h	10
18h				■	■				03F3h	11
00h									03F4h	12
00h									03F5h	13
00h									03F6h	(Reserved)
00h									03F7h	(Reserved)

NOTE: The bytes at addresses 03FBh and 03FCh have the least-significant bit = 1, but this bit is not right-extended into the 9th column because '?' lies outside of the special range C0h through DFh.

Example: Question mark (ASCII 3Fh) in the standard 8 x 8 dot cell.

Value	7	6	5	4	3	2	1	0	Address	Scan Line
78h		■	■	■	■				13F0h	0
CCh	■	■			■	■			13F1h	1
0Ch					■	■			13F2h	2
18h				■	■				13F3h	3
30h			■	■					13F4h	4
00h									13F5h	5
30h			■	■					13F6h	6
00h									13F7h	7

Example: Question mark (ASCII 3Fh) in the alternate 8 x 8 dot cell.

Value	7	6	5	4	3	2	1	0	Address	Scan Line
3Ch			■	■	■	■			13F8h	0
42h		■					■		13F9h	1
02h							■		13FAh	2
04h						■			13FBh	3
08h					■				13FCh	4
00h									13FDh	5
08h					■				13FEh	6
00h									13FFh	7

Output Circuitry

The output circuitry contains the logic and buffers required to interface the video display controller board with a video display. The output circuitry can directly drive a composite video monitor, an internal monitor (COMPAQ PORTABLE 286 only), an RGBI TTL input monitor, or a television, using an external RF modulator (not supplied).

The RGBI, composite, and RF modulator outputs are normally only active in the low-scan mode. The internal monitor interface is always enabled. When COMPAQ Dual-Mode Monitors are used with the COMPAQ DESKPRO 286, Jumpers J3 and J5 are set to enable all video outputs for both modes.

7.3 PROGRAMMING THE VIDEO DISPLAY CONTROLLER BOARD

The video display controller board is an I/O-mapped and memory-mapped (video memory) board. Table 7-1 lists the I/O addresses.

Table 7-1. Video Display Controller Board I/O Addresses

I/O Addr.	Read or Write	Register Description
3D4h	W	6845 Index
3D5h	R/W	6845 Data
3D8h	W	Mode
3D9h	W	Color
3DAh	R	Status
3DBh	W	Reset Lightpen
3DCh	W	Set Lightpen

6845 INDEX AND DATA REGISTERS (3D4h AND 3D5h)

The 6845 CRT controller is addressed as two port addresses. One port (3D4h) accesses the Index register. The other port (3D5h) accesses the Data register.

The CRT controller has 19 internal registers. The Index register counts as one of these, although it serves as a pointer to the other registers.

To write to or read from, a 6845 register:

1. Load the 6845's register number into the Index register (3D4h).

2. Write or read the byte to/from the Data register (3D5h).

The registers pointed to with Index register values of 00h to 0Bh directly control the timing of the CRT controller and the associated waveform profiles which drive the display monitors. Before changing any of the default parameters in these registers, be sure that the environment is understood (i.e., which monitors are connected to the video display controller and the timing that each display requires) for proper operation.

The initial register values are listed in Table 7-2.

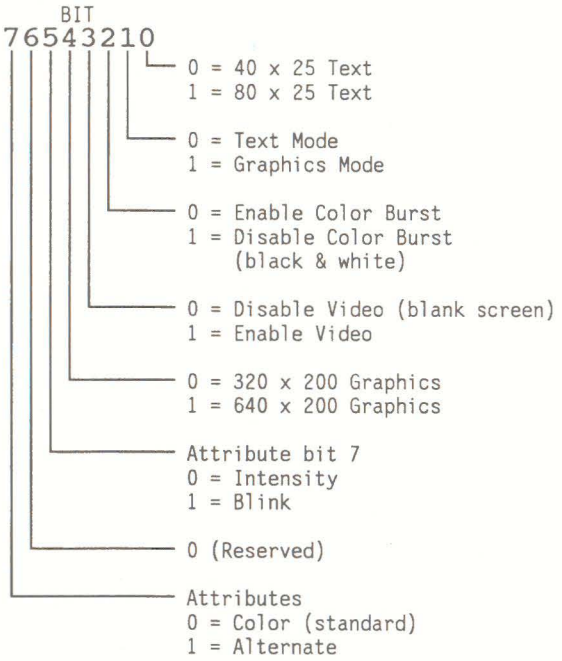
Table 7-2. Initial Values for 6845 Internal Registers

Index Reg.	Register Description	Read or Write	Recommended Values (Default) 40x25 Low-Scan	80x25 High-Scan	80x25 Low-Scan	Graphics Low-Scan
00h	Horizontal Total (characters)	W	38h	71h	71h	38h
01h	Horizontal Displayed (characters)	W	28h	50h	50h	28h
02h	Horizontal Sync Position (characters)	W	2Dh	5Ah	5Ah	2Dh
03h	Horizontal Sync Width (characters)	W	0Ah	0Ah	0Ah	0Ah
04h	Vertical Total (rows)	W	1Fh	19h	1Fh	7Fh
05h	Vertical Total Adjust (lines)	W	06h	06h	06h	06h
06h	Vertical Displayed (rows)	W	19h	19h	19h	64h
07h	Vertical Sync Position (rows)	W	1Ch	19h	1Ch	70h
08h	Interlace Mode & Skew	W	02h	02h	02h	02h
09h	Character Height (lines)	W	07h	0Dh	07h	01h
0Ah	Cursor Start (line)	W	06h	0Bh	06h	06h
0Bh	Cursor End (line)	W	07h	0Ch	07h	07h
0Ch	Display Start Address (high)	R/W	00h	00h	00h	00h
0Dh	Display Start Address (low)	R/W	00h	00h	00h	00h
0Eh	Cursor Address (high)	R/W	00h	00h	00h	00h
0Fh	Cursor Address (low)	R/W	00h	00h	00h	00h
10h	Lightpen Address (high)	R	XXh	XXh	XXh	XXh
11h	Lightpen Address (low)	R	XXh	XXh	XXh	XXh

Note: Recommended values apply to COMPAQ Monitors.
chrs = characters (i.e., character count)
lines = horizontal scan lines elements which make up a character row
row = vertical character units (i.e., row = 8 or 14 lines)
X = undefined

MODE REGISTER (3D8h, WRITE-ONLY)

This register selects the current video-display mode in conjunction with other 6845 registers.



Bit 0. If bit 0 = 0, text is displayed in a 40-column mode. In the 40-column modes, the clock for the video and timing logic is divided by two.

If bit 0 = 1, text is displayed in an 80-column mode.

Bit 1. If bit 1 = 0 , the text mode is selected.

If bit 1 = 1, the bit-mapped graphics mode is selected.

Bit 2. If bit 2 = 0, color encoding on the composite video output is enabled. This bit only affects the composite video outputs; the other video outputs are unaffected.

If bit 2 = 1, the reference color burst signal for the composite video output is disabled (black and white display).

Bit 3. If bit 3 = 0, the entire display is blanked, but the sync signals are still active.

If bit 3 = 1, the screen is displayed normally.

Bit 4. If bit 4 = 0, the display format is 320 x 200 in the graphics modes.

If bit 4 = 1, the display format is 640 x 200 in the graphics modes (Mode register bit 1 = 1).

The 640 x 200 mode is a 1 bit-per-pixel format, while the 320 x 200 mode is 2 bits per pixel.

Bit 5. This bit has meaning in the text modes only.

If bit 5 = 0, then bit 7 of the text-attribute byte controls the background intensity function.

If bit 5 = 1, then bit 7 of the text-attribute byte controls the blinking function.

Bit 6. Reserved (always 0).

Bit 7. This bit has meaning in the text modes only.

If bit 7 = 0 (standard), the text is displayed with the color attributes (color foreground and background). See the section on video display modes.

If bit 7 = 1, the text is displayed with the alternate attributes that defines a white or black foreground or background and text underlining capability. This mode is only available when in the high-scan mode. The low-scan mode uses the color attributes regardless of the state of this bit.

COLOR REGISTER (3D9h, WRITE-ONLY)

The Color register specifies:

- A mode-dependent color for the background, foreground, or border
- Supplemental video intensity
- Standard or alternate color set for the 320 x 200 graphics mode

The color displayed on the screen is a result of the Color register values and the colors specified in video memory for each display location.

In the two graphics modes, either 1 or 4 colors may be displayed at once. In the text modes, 16 foreground and 8 background colors can be displayed simultaneously.

BIT
76543210
Set bits (=1) enable red, green, blue, or intensity
I R G B Displayed Color
0 0 0 0 Black
0 0 0 1 Blue
0 0 1 0 Green
0 0 1 1 Cyan
0 1 0 0 Red
0 1 0 1 Magenta
0 1 1 0 Brown
0 1 1 1 White
1 0 0 0 Gray
1 0 0 1 Light Blue
1 0 1 0 Light Green
1 0 1 1 Light Cyan
1 1 0 0 Light Red
1 1 0 1 Light Magenta
1 1 1 0 Yellow
1 1 1 1 Intense White
1 = Supplemental intensity enabled
Color Set
0 = Standard (green, red, brown)
1 = Alternate (cyan, magenta, white)
00 (Reserved)

Bits 3..0. These four bits select a mode-dependent color.

In the 640 x 200 graphics mode, they select the color of an active pixel.

In the 320 x 200 graphics mode, they select the color of an inactive pixel, or background.

In the 40 x 25 text mode, they select the color of the overscanned border.

Bit 4. If bit 4 = 0, unintensified colors are selected for both the 320 x 200 graphics mode and the background colors in the text modes.

If bit 4 = 1, intensified colors are selected for both the 320 x 200 graphics mode, and background colors in the text modes.

Bit 5. Selects the color set used in the 320 x 200 graphics mode.

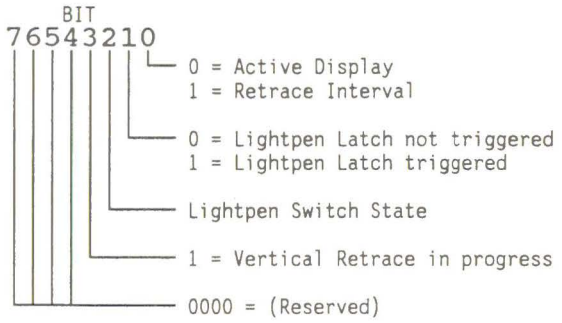
If bit 5 = 0, the standard color set is selected. The standard set consists of green, red, and brown.

If bit 5 = 1, the alternate color set is selected. The alternate set consists of cyan, magenta, and white.

Bits 7..6. Bits 7 and 6 are always 0 (reserved).

STATUS REGISTER (3DAh, READ-ONLY)

The Status register contains real-time event status information.



Bit 0. If bit 0 = 0, the video raster is on the active (displayed) area of the screen

If bit 0 = 1, the video raster is in a horizontal or vertical retrace period

Bit 1. This bit reflects the state of the lightpen latch.

If bit 1 = 1, the lightpen has triggered--the 6845 lightpen address registers may contain a valid address. The state of the lightpen latch can be cleared by writing to port 3DBh and set by writing to 3DCh.

Bit 2. This bit reflects the state of the lightpen switch signal of the lightpen interface connector. This signal is not latched or debounced.

Bit 3. This bit reflects the state of the vertical sync signal.

If bit 3 = 1, the vertical retrace signal is active.

CLEAR OR SET LIGHTPEN LATCH (3DBh AND 3DCh, WRITE-ONLY)

By writing any value to port 3DBh, the lightpen latch bit of the Status register will be reset to 0.

By writing any value to port 3DCh, the lightpen latch bit of the Status register will be set to 1.

Bit 1 of the Status register (3DAh) defines the lightpen latch status.

7.4 VIDEO DISPLAY MODES

The video display controller board displays either graphics or text.

Text displays are character-oriented. The dot patterns for the display is stored in a character-generator ROM. Text on COMPAQ Monitors is normally displayed in the high-scan mode (see COMPAQ Dual-Mode Monitors).

Graphics displays are pixel-oriented. The color of each pixel is specified in video memory. A pixel is the smallest controllable display element--a single dot on the screen. Graphics on COMPAQ Monitors are displayed in the low-scan mode.

Figure 7-6 compares the pixel patterns for the 9 x 14 and 8 x 8-pixel text characters.

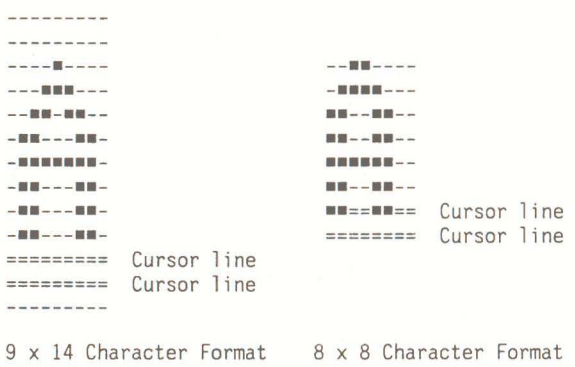


Figure 7-6. Comparison of Text Character Formats

Text Displays

For text displays, the video display controller board uses two bytes of video memory to define each character: the character byte and the attribute byte.

The character byte (even address) is sent to the character generator. The character generator provides the patterns for that character code.

The attribute byte (odd address) specifies the foreground and background color to use for the character and whether the character should be intensified or blinking (See the Mode register)

Table 7-3 lists the character codes and the resulting characters defined in the character generator. The table displays the characters in a hexadecimal format. For example, 20h is the value for the space character.

Table 7-3. Character Codes

Figure 7-7 shows the text attribute byte values (with mode register bit 7 = 0).

BIT
7 6 5 4 3 2 1 0
Set bits (=1) enable red, green, blue, or intensity
I R G B Displayed Color
0 0 0 0 Black
0 0 0 1 Blue
0 0 1 0 Green
0 0 1 1 Cyan
0 1 0 0 Red
0 1 0 1 Magenta
0 1 1 0 Brown
0 1 1 1 White
1 0 0 0 Gray
1 0 0 1 Light Blue
1 0 1 0 Light Green
1 0 1 1 Light Cyan
1 1 0 0 Light Red
1 1 0 1 Light Magenta
1 1 1 0 Yellow
1 1 1 1 Intense White
Set bits (=1) enable red, green, blue, or intensity (or blink--see Mode Register Bit 5 for background color. (Use table above for color values.)

Figure 7-7. Attribute Byte for Color Text

Figure 7-8 shows the alternate text-attribute byte values (with Mode register bit 7 = 1)

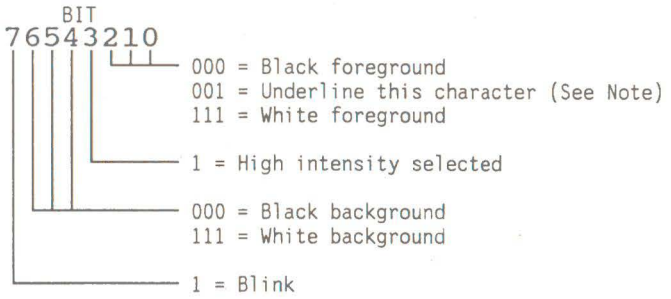


Figure 7-8. Alternate Attribute Byte (80 x 25, High-Scan Text Only)

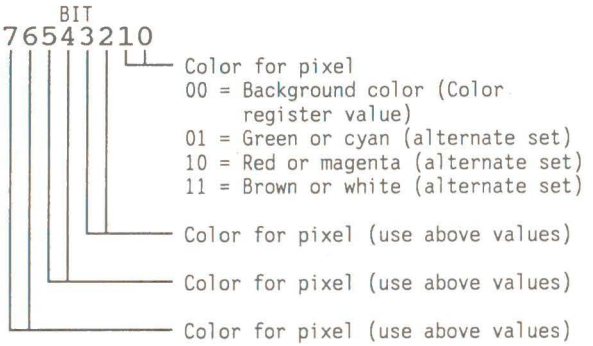
NOTE: Hardware draws the underline by turning on all 9 pixels of scan line 13 (lowest) of the character cell.

Graphics Displays

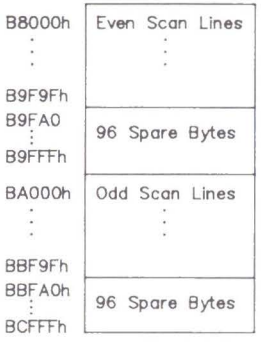
For pixel-oriented displays, the video display controller board uses video memory as the source of the patterns to display.

In the 640 x 200-pixel graphics mode, a single byte of video memory defines the state of eight pixels. Bit 7 is the left-most pixel on the display. The color used for active pixels is specified in the color register.

In the 320 x 200-pixel graphics mode, a single byte defines the state of four pixels (two bits per pixel). The two bits that define a pixel specify one of three colors from the standard or alternate color set or the background color. Bits 7 and 6 control the left-most pixel.


BIT
76543210
Color for pixel
00 = Background color (Color register value)
01 = Green or cyan (alternate set)
10 = Red or magenta (alternate set)
11 = Brown or white (alternate set)
Color for pixel (use above values)
Color for pixel (use above values)
Color for pixel (use above values)

For the graphics modes, the video memory is divided into separate blocks for the even and odd scan lines. Figure 7-9 shows the format of video memory for the graphic modes.



Addresses for Graphics

Row	First Column	Last Column
1	B8000h	B804Fh
2	BA000h	BA04Fh
3	B8050h	B809Fh
4	BA050h	BA09Fh
:	:	:
197	B9F00h	B9F4Fh
198	BBF00h	BBF4Fh
199	B9F50h	B9F9Fh
200	BBF50h	BBF9Fh

Figure 7-9. Format of Video Memory for the Graphic Modes

7.5 MONITORS SUPPORTED

The video display controller board supports four types of monitors:

- COMPAQ Dual-Mode Monitors.
- Red-Green-Blue (RGB) color monitors that connect to the standard DB-9 (9-pin) connector, including the COMPAQ Color Monitor in 200-line Mode.
- Monochrome or color monitors that require composite-video signals may use an RCA-type connector or a recessed Berg connector.

COMPAQ Dual-Mode Monitors

The standard COMPAQ monitor is dual-mode. Dual-mode means that there are two different display modes, with different scanning frequencies for each mode.

The high-scan mode has a horizontal scan frequency of 18.5 kHz and a vertical scan frequency of 50 Hz, non-interlaced. High scan supports the text modes, using a 9 x 14-pixel character block. This mode has 350 active vertical lines for 25 rows of 14-pixel high characters, and 720 horizontal pixels for 80 columns of 9-pixel wide characters.

When the high-scan mode is selected, the monitor mode line switches to select the 9 x 14 character set in the character generator.

The low-scan mode has a horizontal frequency of 15.7 kHz, and a vertical frequency of 60 Hz, non-interlaced. This mode is compatible with most television and RGB displays that use 200 active scan lines. The low-scan mode uses an 8 x 8 character block for text, and is the only mode used for graphics.

To select the high-scan mode, program the 6845 according to the "80 x 25 High Scan" column in Table 7-6.

Characters are displayed in the 80 x 25-character format, with a 9 x 14-dot matrix on COMPAQ Dual-Mode Monitors, or an 8 x 8-dot matrix using other monitors.

COMPAQ Dual-Mode Monitors can accept two scan (sync) frequencies from the video display controller board. One scan mode displays high-quality text (9 x 14-pixel characters). The other mode displays graphics.

The high- and low-scan modes can also be easily accessed using either of the following methods:

- Keyboard selection (using COMPAQ MS-DOS and XENIX) Simultaneously pressing the multiple key combination of CTRL, ALT, and < (LESS THAN) keys will switch into low-scan mode. Simultaneously pressing the multiple key combination of CTRL, ALT, and > (GREATER THAN) keys will switch into high-scan mode.
- COMPAQ MS-DOS, Version 3 MODE Command. Refer to MS-DOS Version 3 Reference Guide for more information on the MODE command.

RGBI Monitors

RGBI monitors receive their video signals in the form of separate lines for the red, green, and blue colors, intensity, horizontal sync, and vertical sync. These are all TTL-level signals. With four signals (red, green, blue, and intensity) to specify color, 16 colors or shades of gray are available. Monitors that do not support the intensity signal are limited to eight colors.

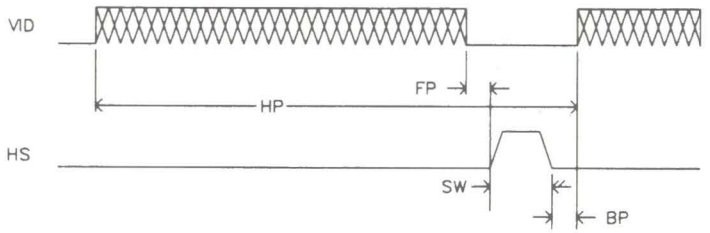
The COMPAQ Color Monitor is compatible with this video display controller board. However, it is restricted to only the 200-scan line, 16 color operation.

Composite Video Monitors

Composite video monitors, or other video equipment with composite video inputs, connect to the RCA-type jack provided on the mounting bracket. If a monochrome display is used, disable the color burst signal to reduce interference.

An external RF modulator can be connected to either the RCA-type connector or the recessed Berg connector for use with television receivers. The Berg connector provides the same video signal as the RCA-type connector plus a +12 volt power connection. Due to television bandwidth limitations, 80-column television displays are not recommended.

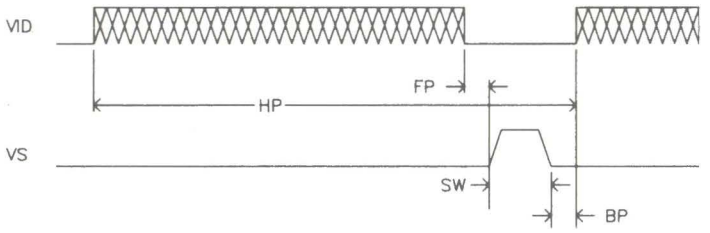
Figure 7-10 shows the timing characteristics for the horizontal sync signals.



Symbol	Parameter	High Scan (Hi Res)	Low Scan (Graphics)
HP	Horizontal Period	54.1 µs	63.7 µs
FP	Front Porch	5.7 µs	6.7 µs
SW	Sync Width	3.8 µs	4.5 µs
BP	Back Porch	6.6 µs	7.8 µs

Figure 7-10. Horizontal Timing

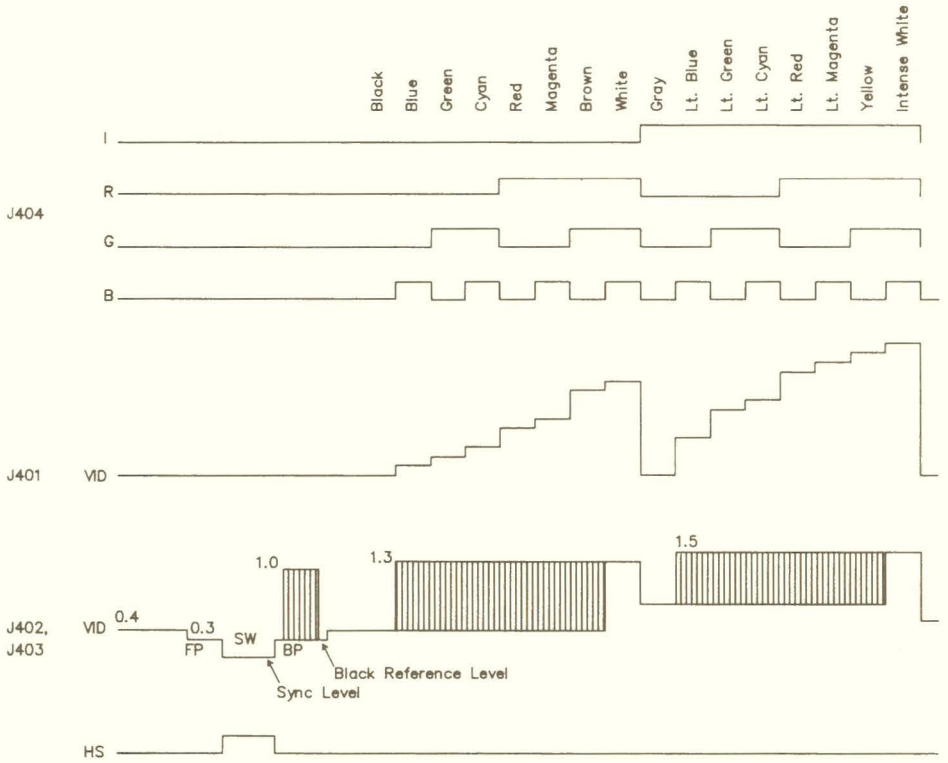
Figure 7-11 shows the timing characteristics for the vertical sync signals.



Symbol	Parameter	High Scan (Hi Res)	Low Scan (Graphics)
VP	Vertical Period	20.00 ms	16.68 ms
FP	Front Porch	0.00 ms	1.53 ms
SW	Sync Width	0.16 ms	0.19 ms
BP	Back Porch	0.92 ms	2.23 ms

Figure 7-11. Vertical Timing

Figure 7-12 shows the characteristics for the video connectors.



Notes: 1. Burst is only present in the 40 x 25 text mode or the 320 x 200 graphics mode.
2. This is a block-frame format without equalization pulses.

Figure 7-12. Video Display Controller Board Output Signal Waveforms

7.6 JUMPERS

Jumpers J1 through J9 are identical on all three video display controller boards. Two additional Jumpers, J10 and J11 have been added to the Version 3 video display controller board to enable the additional 16 Kbytes of RAM provided by the dynamic RAM devices on the controller

Jumpers J1 through J9 change the configuration of the video display controller board. Only J3 and J5 have pins and shorting blocks installed. The remaining jumpers are etched on the controller board.

Table 7-4 lists the jumpers for all three video display controller boards. The jumper arrangement is shown in Figures 7-13 through 7-15.

CAUTION

Modifying etched jumpers invalidates the COMPAQ warranty of the board.

Table 7-4. Jumpers on the Video Display Controller Board

J1 - 8 x 8 Character Set Jumper

The character generator ROM contains two complete sets of 8 x 8 dot lookup tables. The standard table is suitable for all types of monitors. The alternate table provides sharper character sets for 40-column displays on televisions. This jumper is etched on the board.

J1	Configuration
2-3	Standard 8 x 8 cell
1-2	Alternate 8 x 8 cell

(Continued)

Table 7-4. (Continued)

J2 - Vertical Sync Polarity

The vertical sync signals can have positive (standard) or negative polarity. This jumper is etched on the board.

J2	Configuration
1-2	Positive vertical sync (standard)
2-3	Negative vertical sync

J4 - Horizontal Sync Polarity

The horizontal sync signals can have positive (standard) or negative polarity. This jumper is etched on the board.

J4	Configuration
2-3	Positive horizontal sync (standard)
1-2	Negative horizontal sync

J3, J5 - External High-Scan Video

These jumpers control all but the internal monitor. Video outputs will be active in high-scan. They are changed as a set (both to 2-3 or both to 1-2).

J3	J5	Configuration
2-3	2-3	Enable high-scan video on external outputs (standard setting for COMPAQ DESKPRO Computers)
1-2	1-2	Disable high-scan video on external outputs (standard setting for COMPAQ PORTABLE Computers)

(Continued)

Table 7-4. (Continued)

J6 - Enable Mode Signal

This 2-pin jumper connects the MODE signal to pin 7 of the 9-pin connector. The MODE signal is low for high-scan (18.5 kHz) and high for low-scan (15.7 kHz). Cutting this jumper's etch makes pin 7 not connect.

J6	Configuration
1-2	Connect MODE signal to pin 7
n.c.	Disconnect MODE signal from pin 7

J7, J8, J9 - Standard/Alternate Video Display Controller Board Addresses

These jumpers change the video memory base address from B8000h to B0000h. They also change the Video Display Controller Board's I/O address from 3DXh to 3BXh (X = value from 0 to F(h)). These jumpers are etched on the board.

Boards with standard or alternate base addresses are functionally identical.

J7	J8	J9	Configuration
1-2	1-2	1-2	Standard
2-3	2-3	2-3	Alternate

(Continued)

Table 7-4. (Continued)

J10, J11 - Extended Memory (Version 3 Video Display Controller Board only)

These jumpers enable additional video memory. Standard video buffer size is 16K bytes of Dynamic RAM beginning at address B8000h and extending to address BBFFFh. Extended video buffer size is 32K bytes beginning at address B8000h and extending to BFFFFh.

Jumpers J10 and J11 are etched on the board to 16K bytes (standard buffer size), and are changed as a set (both to 2-3 or both to 1-2).

J10	J11	Configuration
2-3	2-3	Standard video memory (16K bytes)
1-2	1-2	Extended video memory (32K bytes)

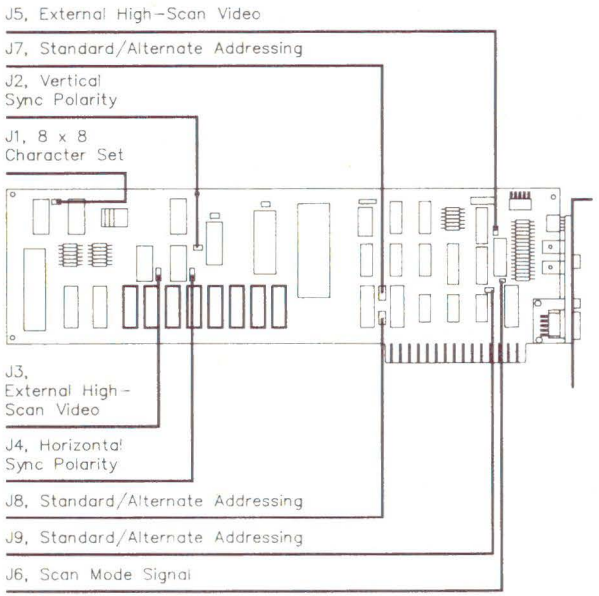


Figure 7-13. Version 1 Video Display Controller Board Jumper Arrangement

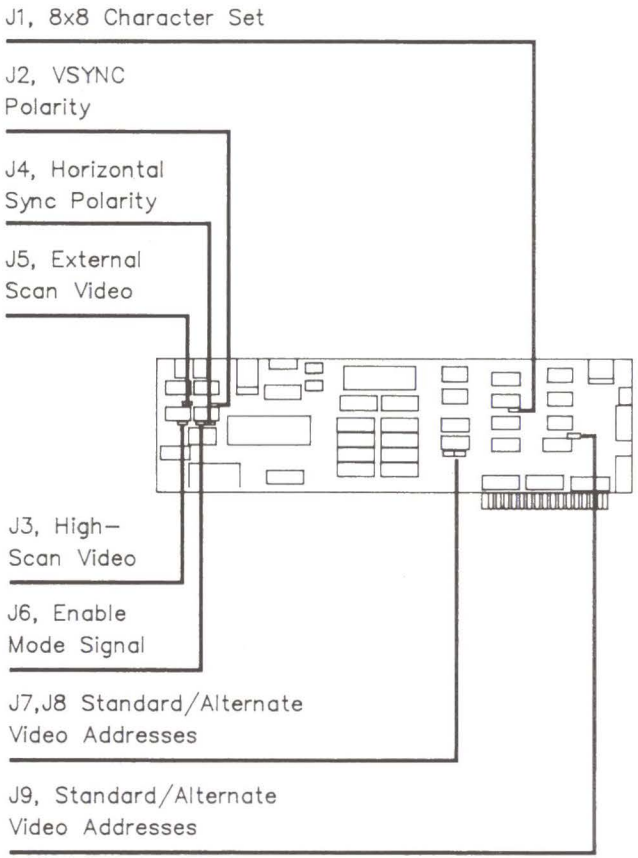


Figure 7-14. Version 2 Video Display Controller Board Jumper Arrangement

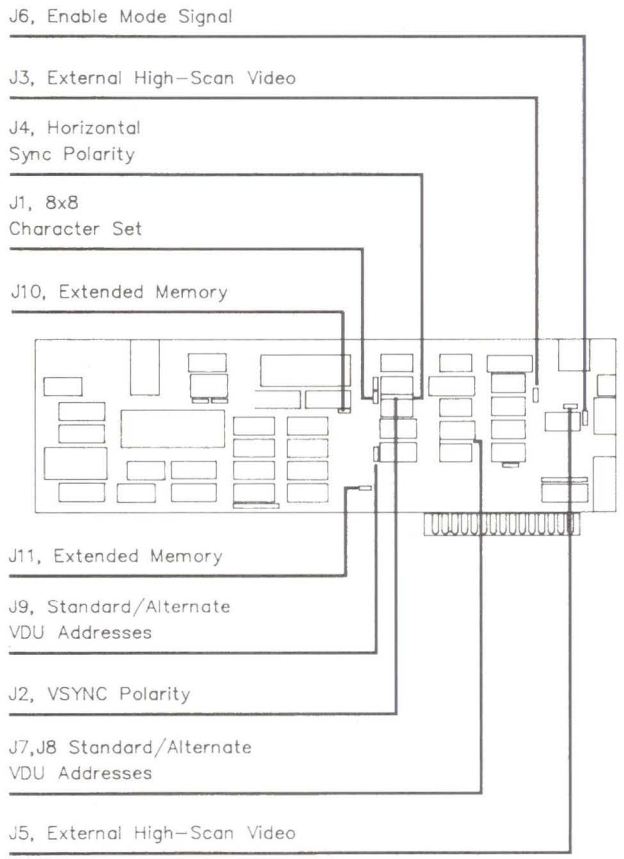


Figure 7-15. Version 3 Video Display Controller Board Jumper Arrangement

7.7 CONNECTORS

Table 7-5 through 7-9 show the video display controller board connector signals.

Figure 7-16 shows the location of the connectors on a Version 1 video display controller board. The connectors are located in the same positions on all three versions of the video display controller board.

Figure 7-17 through 7-19 show the video display controller board connectors.

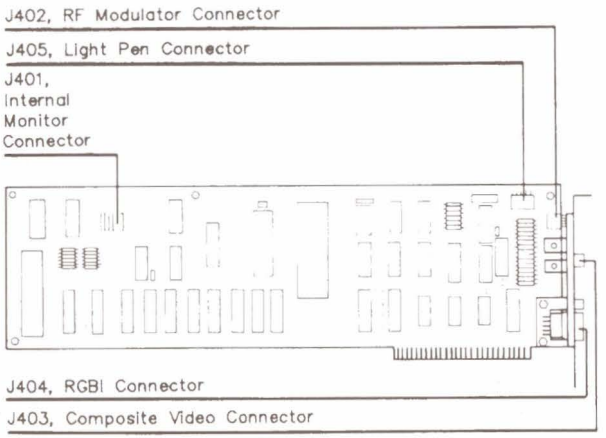


Figure 7-16. Connectors on the Video Display Controller Board

Table 7-5. J401, Internal Monitor Connector Signals

Signal	Pin	I/O	Description
Chassis Ground	11,12	-	Cable Shield
HS	7	O	Horizontal sync is an active-high TTL signal in both level and drive characteristics. The pulse duration is always fixed at 8 characters regardless of the duration programmed in the 6845. Refer to Section 8.5 for the timing characteristics.
MODE	3	O	This TTL signal controls the monitor mode. During a mode change, both horizontal and vertical sync are suppressed for up to 16 vertical frames. The MODE signal is high (= 1) for the low-scan mode, and low (= 0) for the high-scan mode.
Signal Ground	2,4,8	-	This is the ground reference for the TTL signals.
VID	5	O	This analog video output signal ranges from 1.0 Vdc (black) to 2.5 Vdc (white) into 470 to 6800 ohms (impedance). Its ground reference is the video ground signal (pin 6).
Video Ground	6	-	This is the ground reference for the VID signal (pin 5).
VS-	1	O	Vertical sync is an active-low TTL signal in both level and drive characteristics. The pulse duration is always fixed to three scan lines regardless of the duration that is programmed in the 6845's internal registers. Refer to the section 8.5 for the timing characteristics for the vertical sync signals.

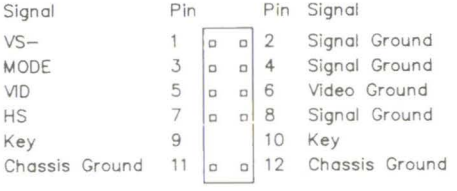


Figure 7-17. J401, Internal Monitor Connector

Table 7-6. J402, RF Modulator Connector Signals

Signal	Pin	I/O	Description
+12 Vdc	1	O	Power
COMPOSITE VIDEO	3	O	This analog signal is the composite video output
Signal Ground	4	-	Reference for composite video

Figure 7-18. J402, RF Modulator Connector

Table 7-7. J403, Composite Video Connector Signals

Signal	Pin	I/O	Description
Chassis Ground	2	-	Reference for composite video
COMPOSITE VIDEO	1	O	This analog signal is the composite video output

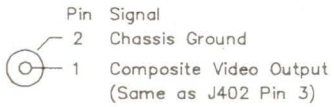


Figure 7-19. J403, Composite Video Connector

Table 7-8. J404, RGBI Video Connector Signals

Signal	Pin	I/O	Description
B	5	O	Blue. Active-high TTL signal.
G	4	O	Green. Active-high TTL signal.
HS	8	O	Horizontal sync is an active-high TTL signal in both level and drive characteristics. The pulse duration is fixed at eight characters regardless of the duration programmed in the 6845. Refer to the "Monitors Supported" section for the timing characteristics.
I	6	O	Intensity. Active-high TTL signal.
MODE	7	O	This signal controls the monitor high- or low-scan mode. During a mode change, both horizontal and vertical sync are suppressed for up to 16 vertical frames. The MODE signal is high for the low-scan mode and low for the high-scan mode.
R	3	O	Red. Active-high TTL signal.
Signal Ground	1,2	-	TTL signal reference.
VS	9	O	Vertical sync is an active-high TTL signal in both level and drive characteristics. The pulse duration is fixed to 3 scan lines regardless of the pulse duration programmed in the 6845. Refer to the "Monitors Supported" section for the timing characteristics.

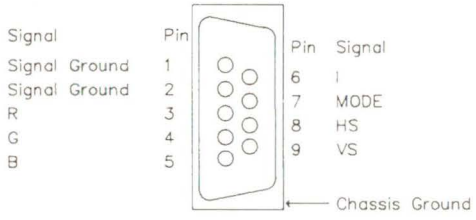


Figure 7-20. J404, RGBI Connector

Table 7-9. J405, Lightpen Connector Signals

Signal	Pin	I/O	Description
+5 Vdc	5	O	+5 Vdc lightpen power source
+12 Vdc	6	O	+12 Vdc lightpen power source
LIGHTPEN SWITCH-	3	I	Active-low signal indicates lightpen switch contact closed
LIGHTPEN TRIGGER-	1	I	Active-low signal indicates lightpen triggered
Signal Ground	4	-	Reference for TTL signals

Figure 7-21. J405, Lightpen Connector

7.8 SCHEMATICS

Figure 7-22 shows the schematics for the Video Display Controller Board Version 1. COMPAQ Computer Corporation does not guarantee the accuracy of the schematics. They are provided to aid in a general understanding of the system operation.

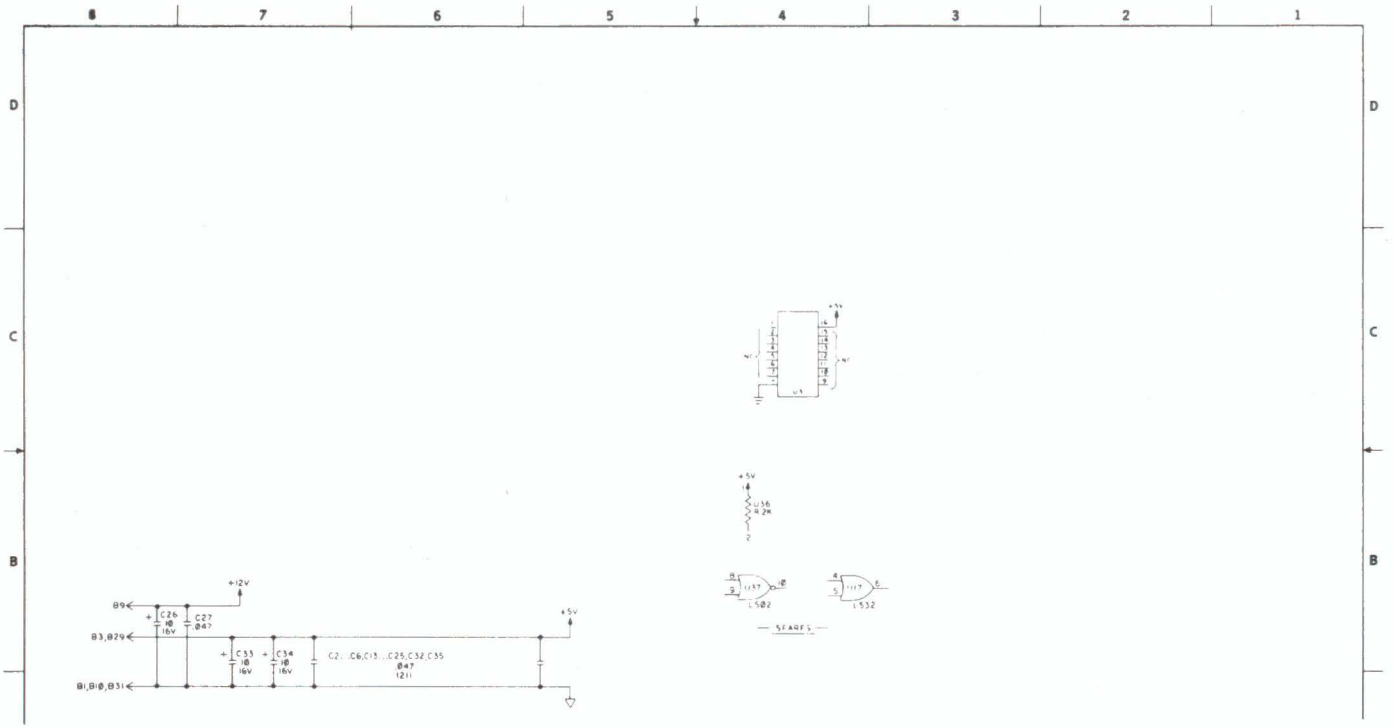


Figure 7-22. Video Display Controller Board Version 1 Schematics (Page 1 of 5)

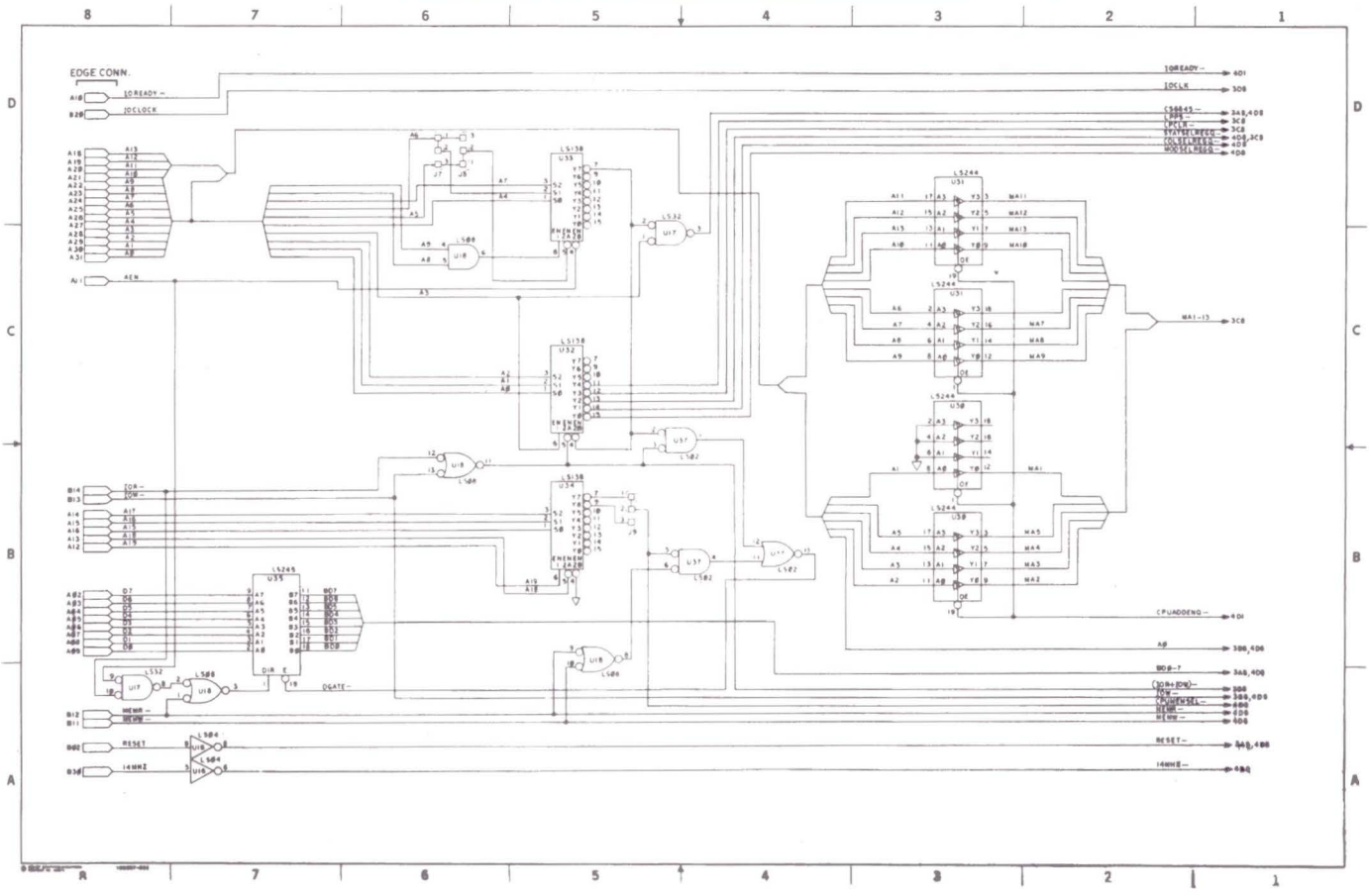


Figure 7-22. Video Display Controller Board Version 1 Schematics (Page 2 of 5)

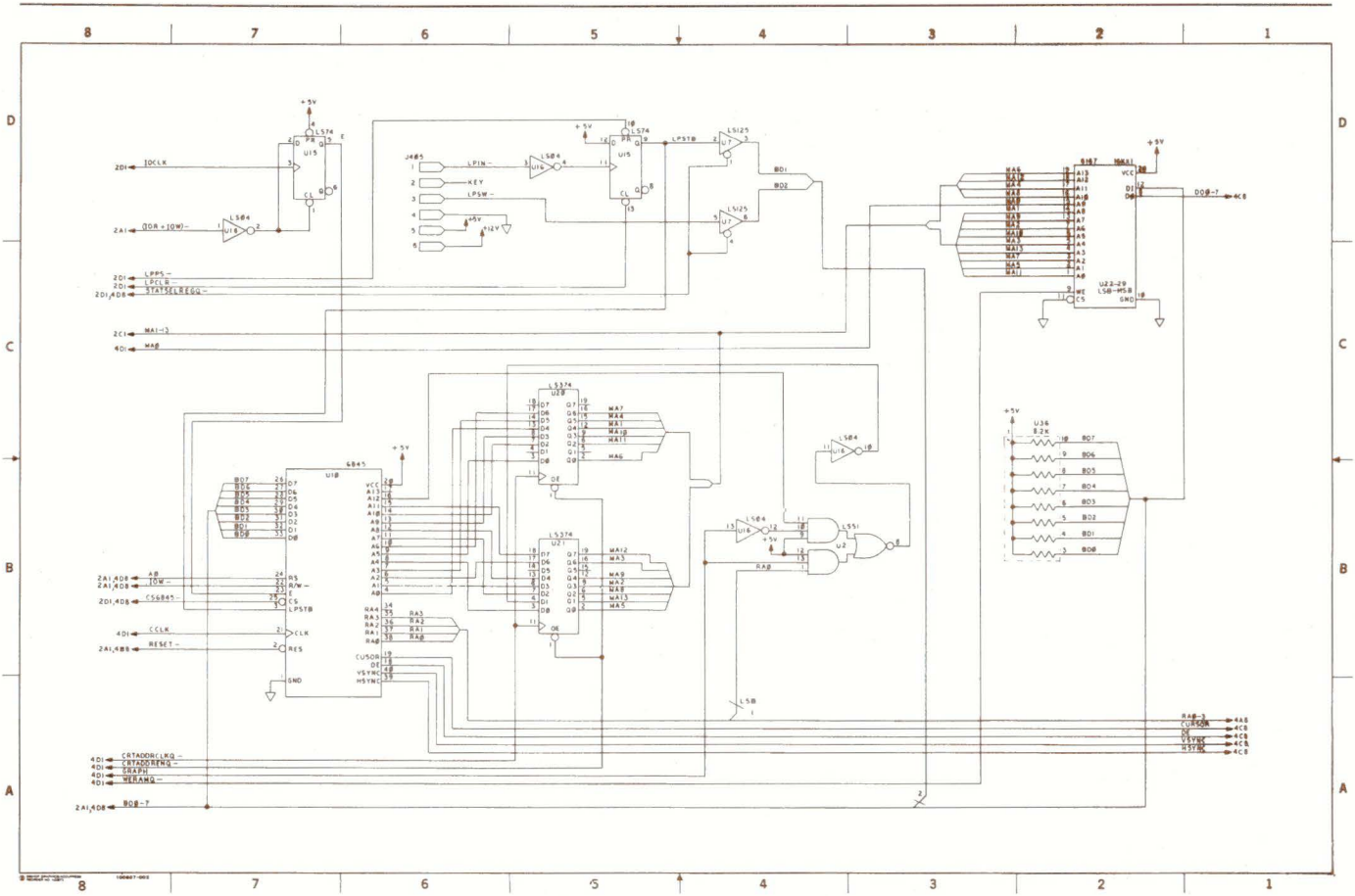


Figure 7-22. Video Display Controller Board Version 1 Schematics (Page 3 of 5)

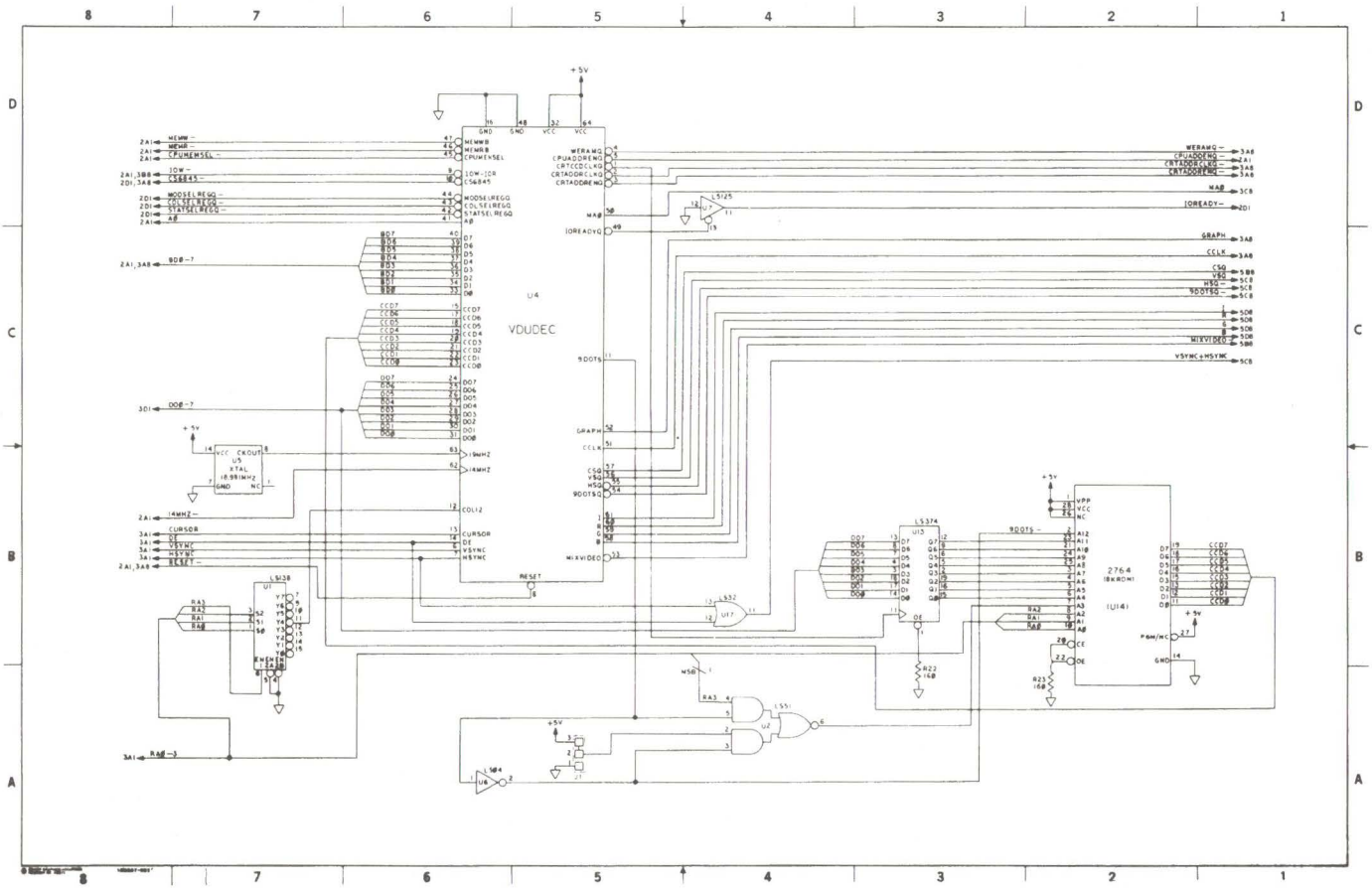


Figure 7-22. Video Display Controller Board Version 1 Schematics (Page 4 of 5)

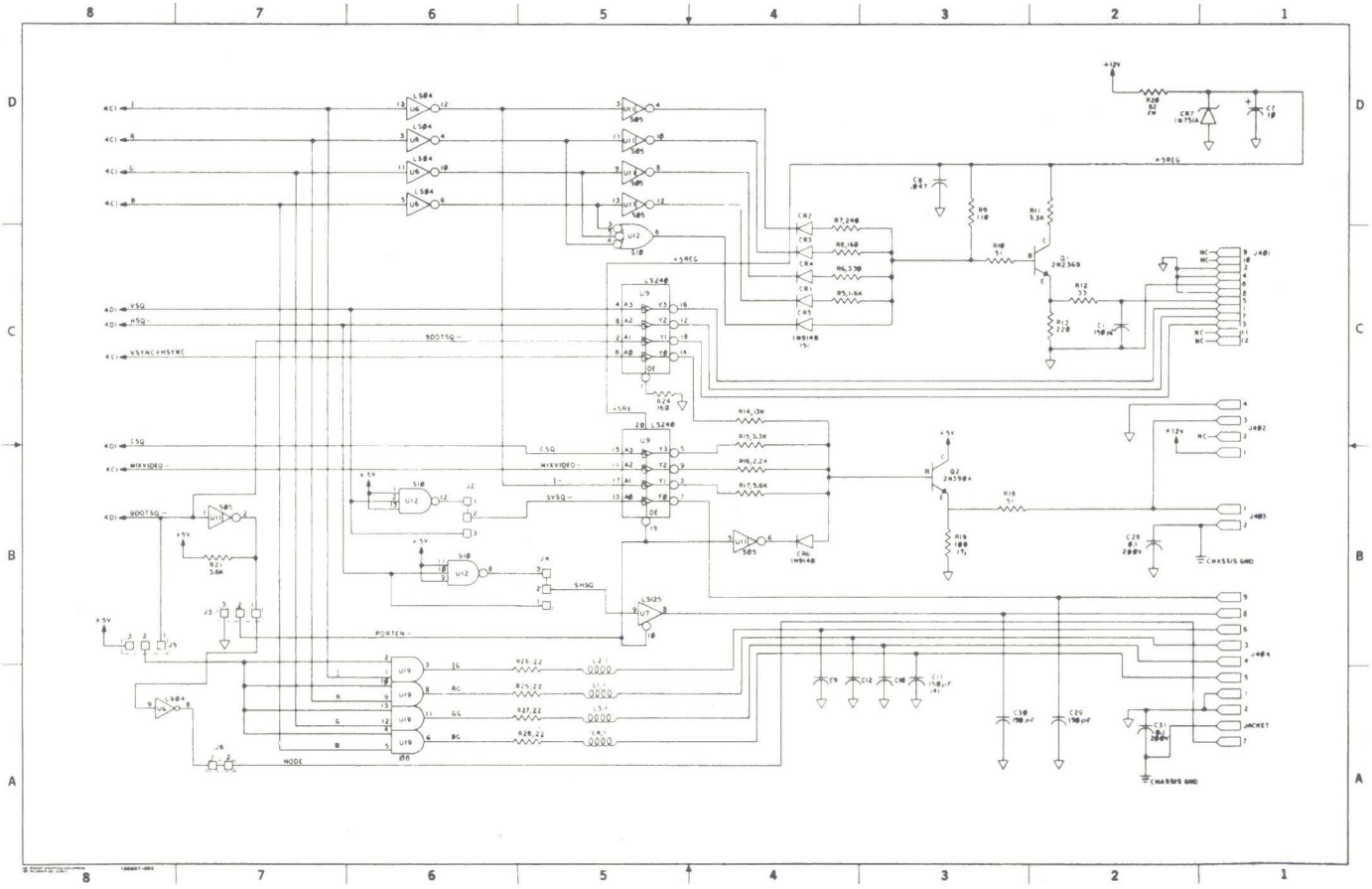


Figure 7-22. Video Display Controller Board Version 1 Schematics (Page 5 of 5)

Figure 7-23 shows the schematics for the Video Display Controller Board Version 2. COMPAQ Computer Corporation does not guarantee the accuracy of the schematics. They are provided to aid in a general understanding of the system operation.

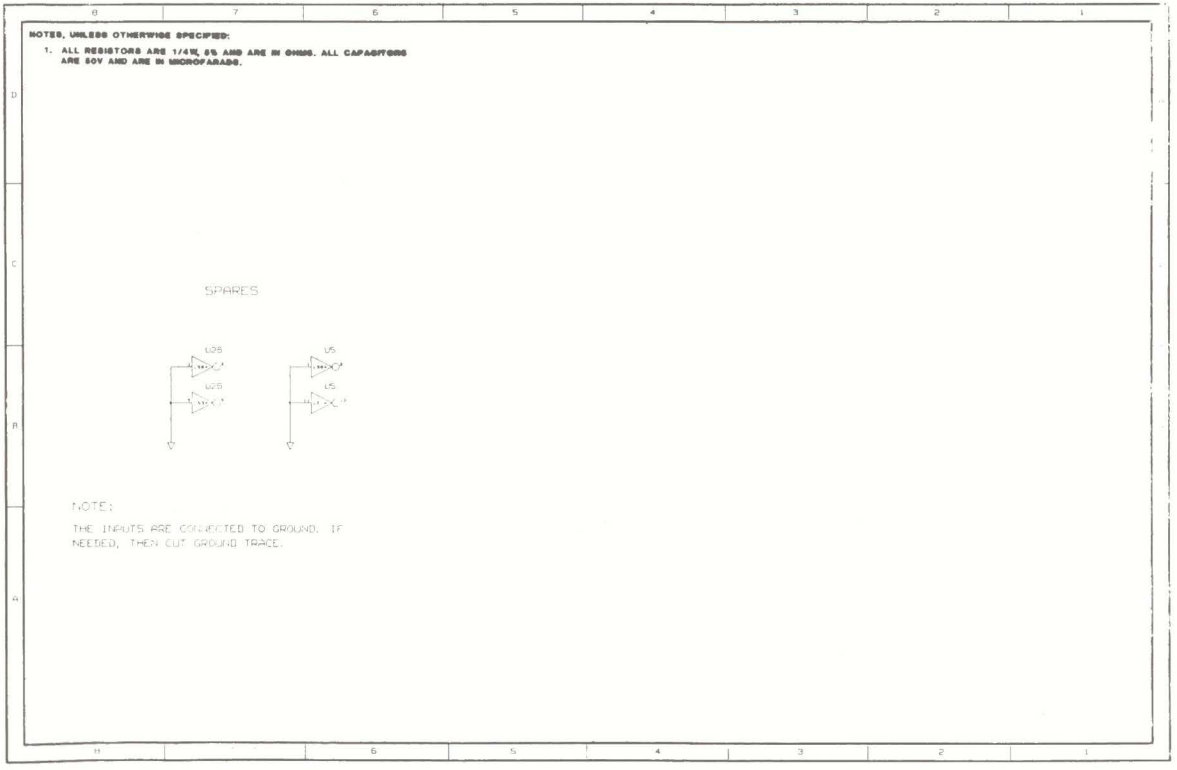


Figure 7-23. Video Display Controller Board Version 2 Schematics (Page 1 of 7)

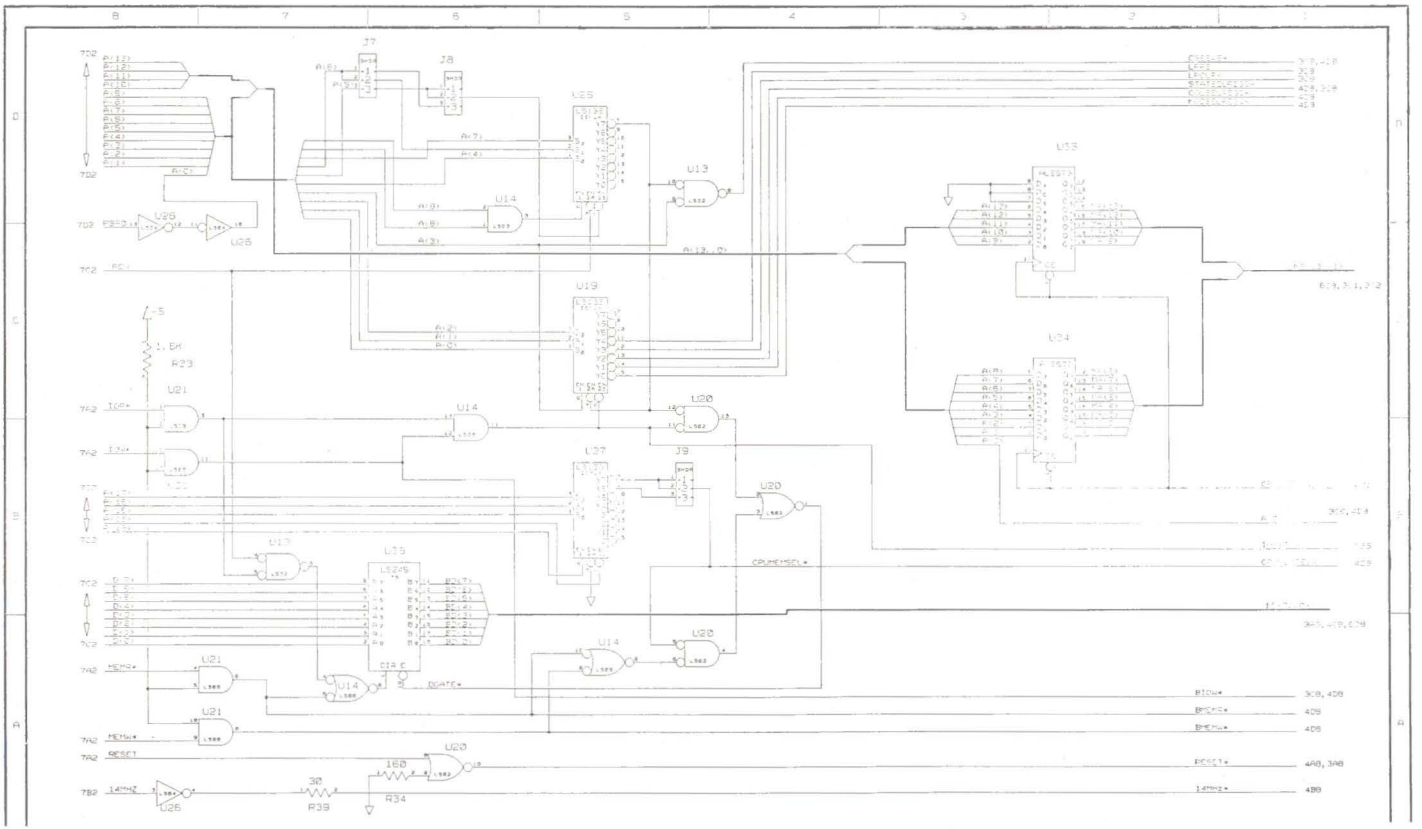


Figure 7-23. Video Display Controller Board Version 2 Schematics (Page 2 of 7)

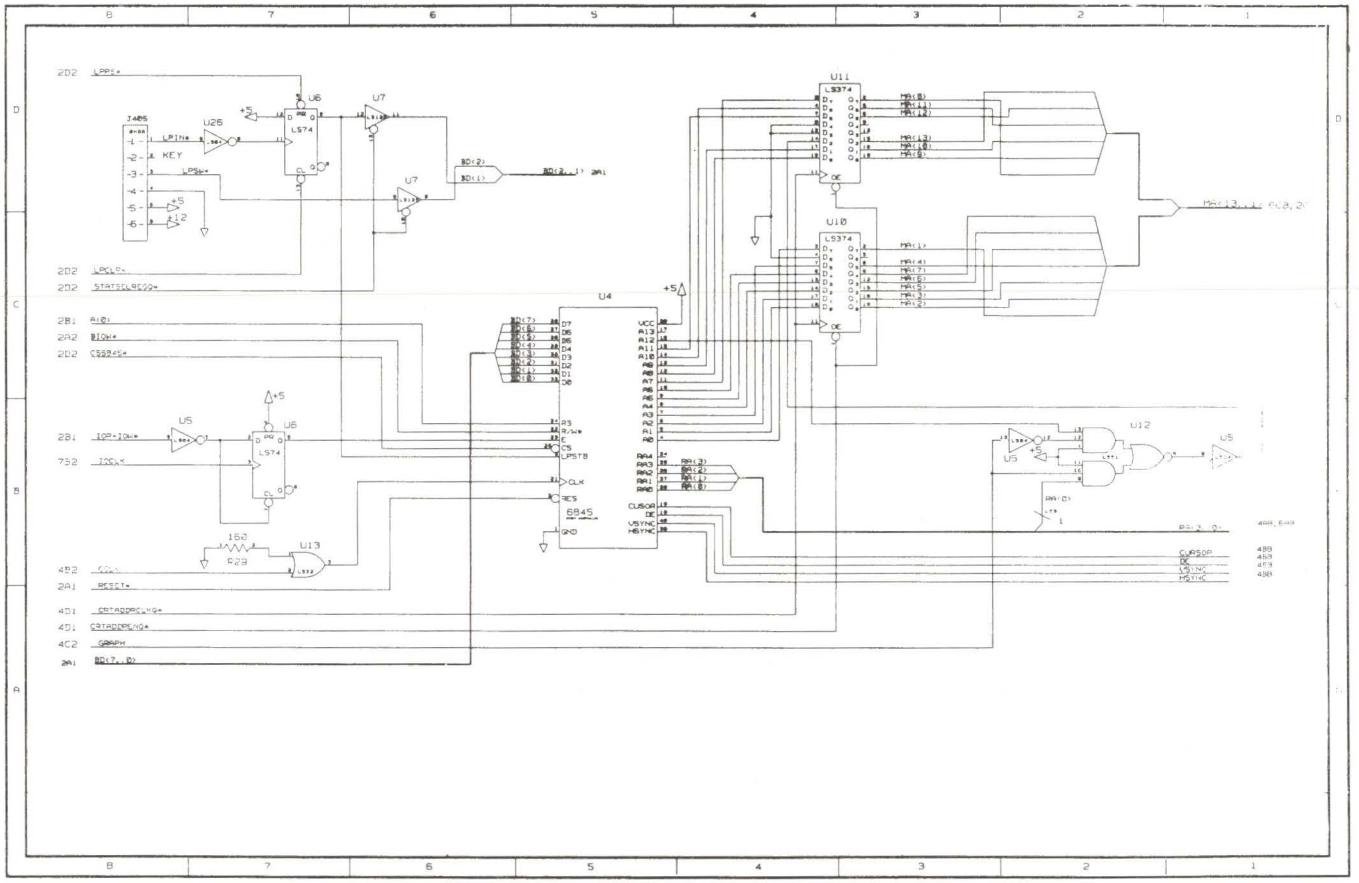


Figure 7-23. Video Display Controller Board Version 2 Schematics (Page 3 of 7)

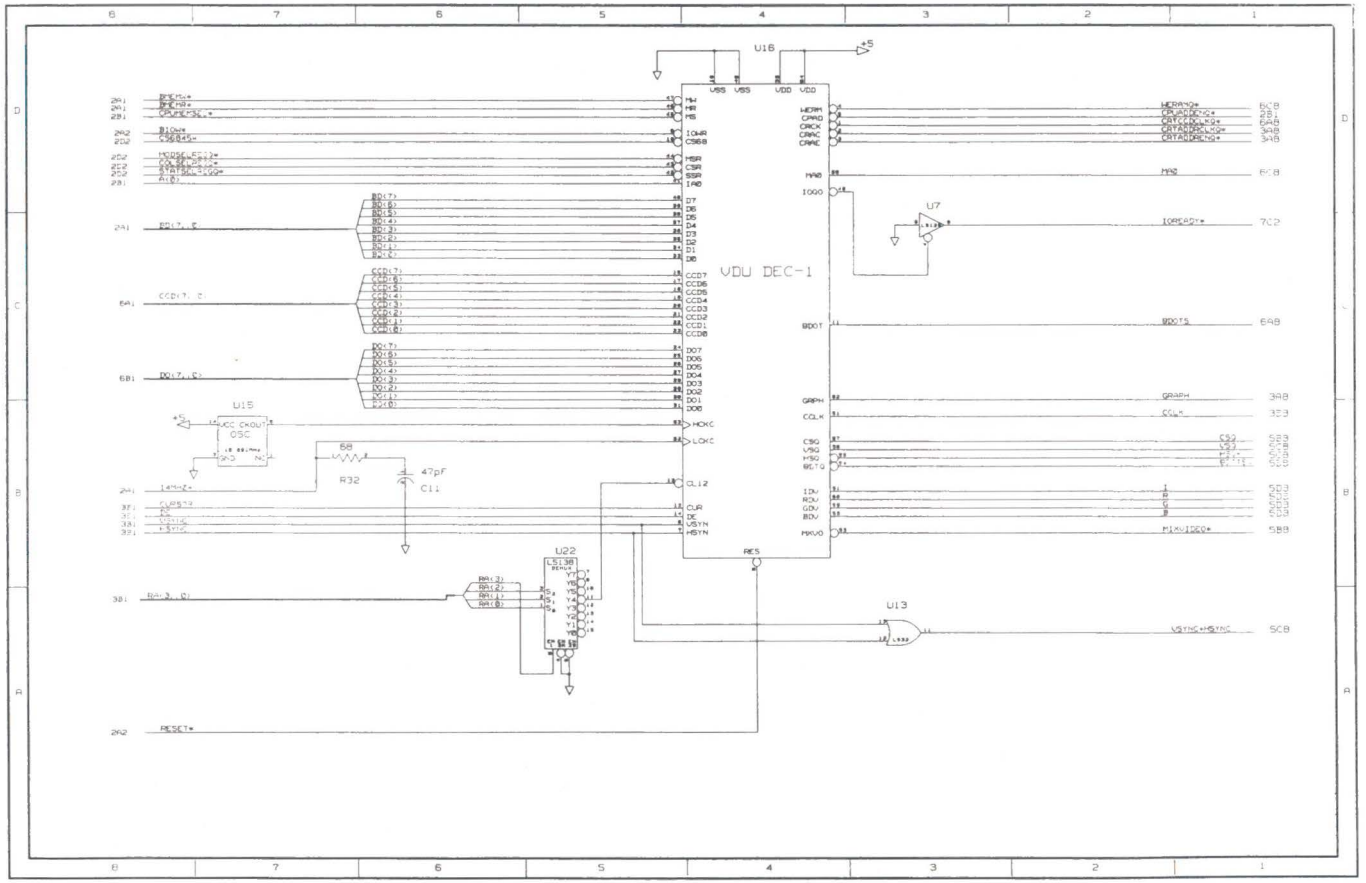


Figure 7-23. Video Display Controller Board Version 2 Schematics (Page 4 of 7)

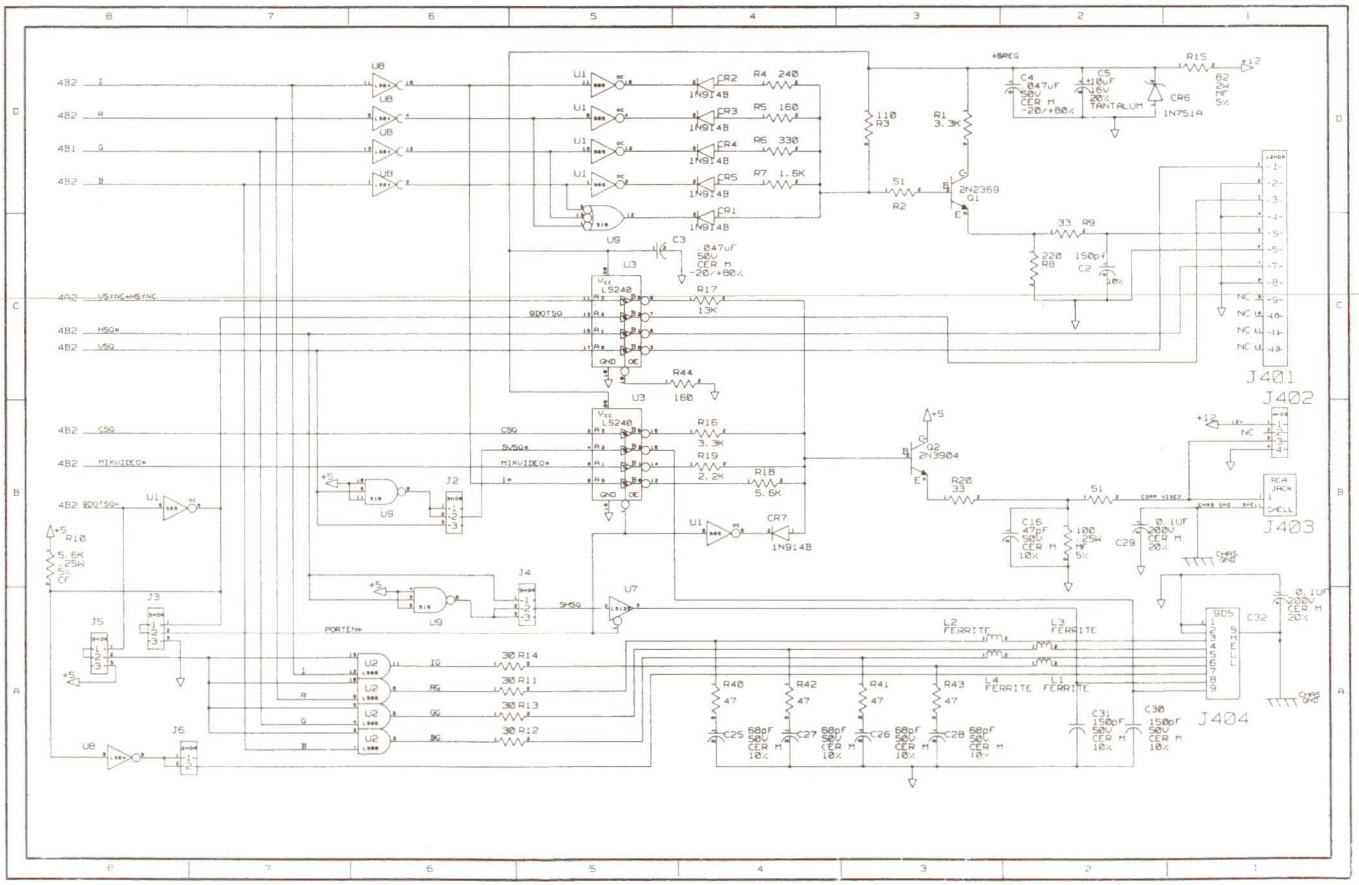


Figure 7-23. Video Display Controller Board Version 2 Schematics (Page 5 of 7)

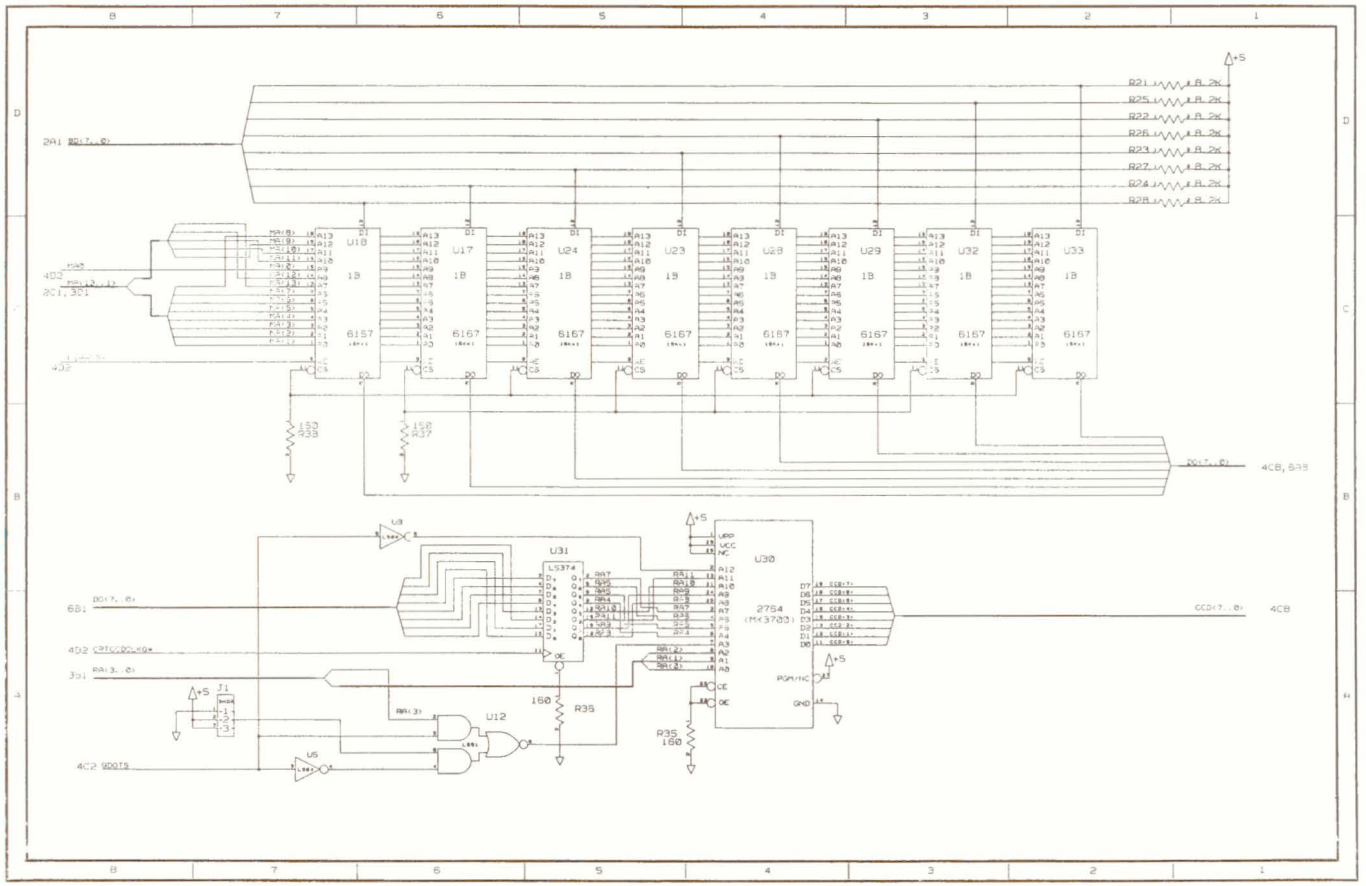


Figure 7-23. Video Display Controller Board Version 2 Schematics (Page 6 of 7)

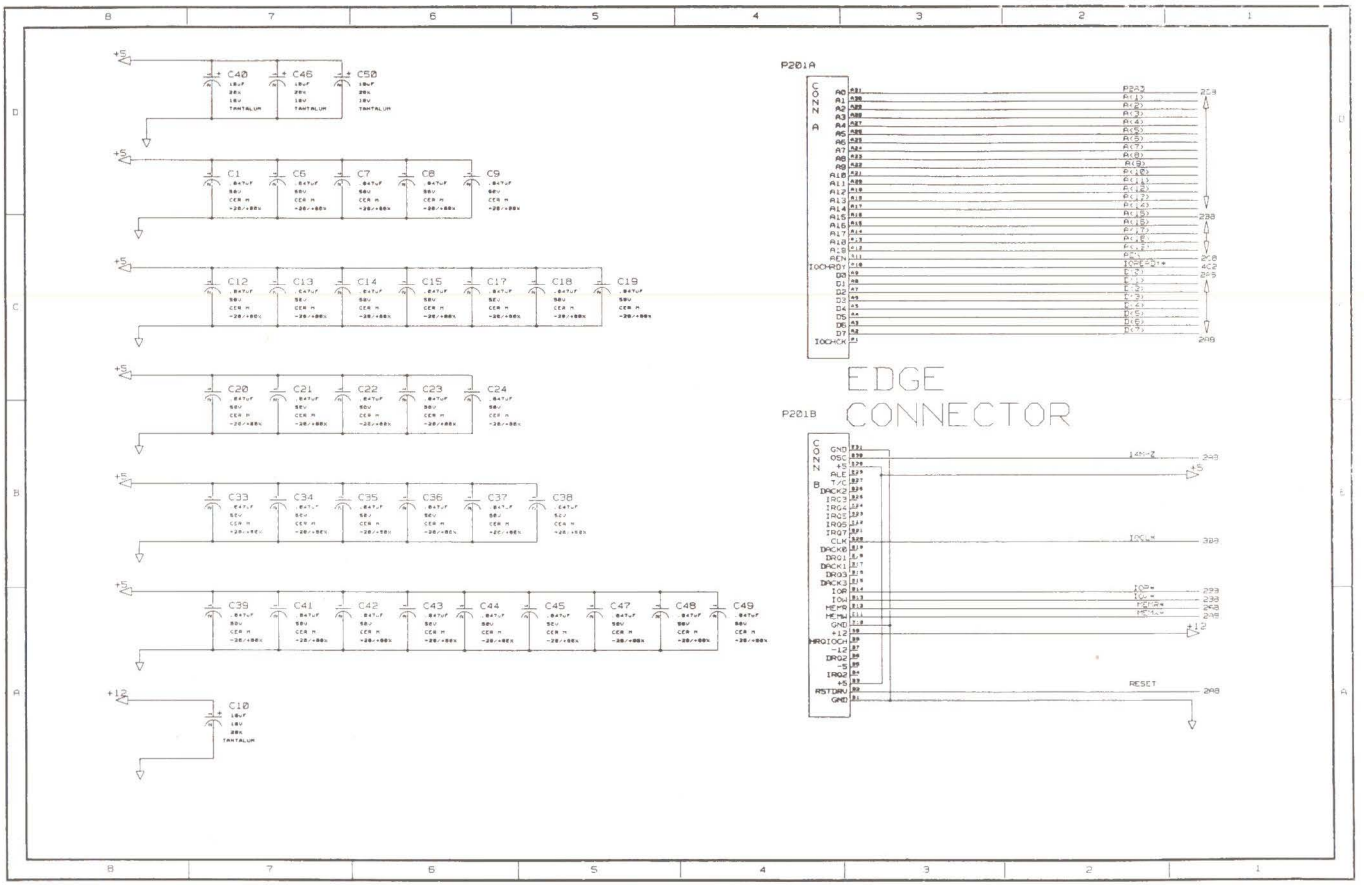


Figure 7-23. Video Display Controller Board Version 2 Schematics (Page 7 of 7)

Figure 7-24 shows the schematics for the Video Display Controller Board Version 3. COMPAQ Computer Corporation does not guarantee the accuracy of the schematics. They are provided to aid in a general understanding of the system operation.

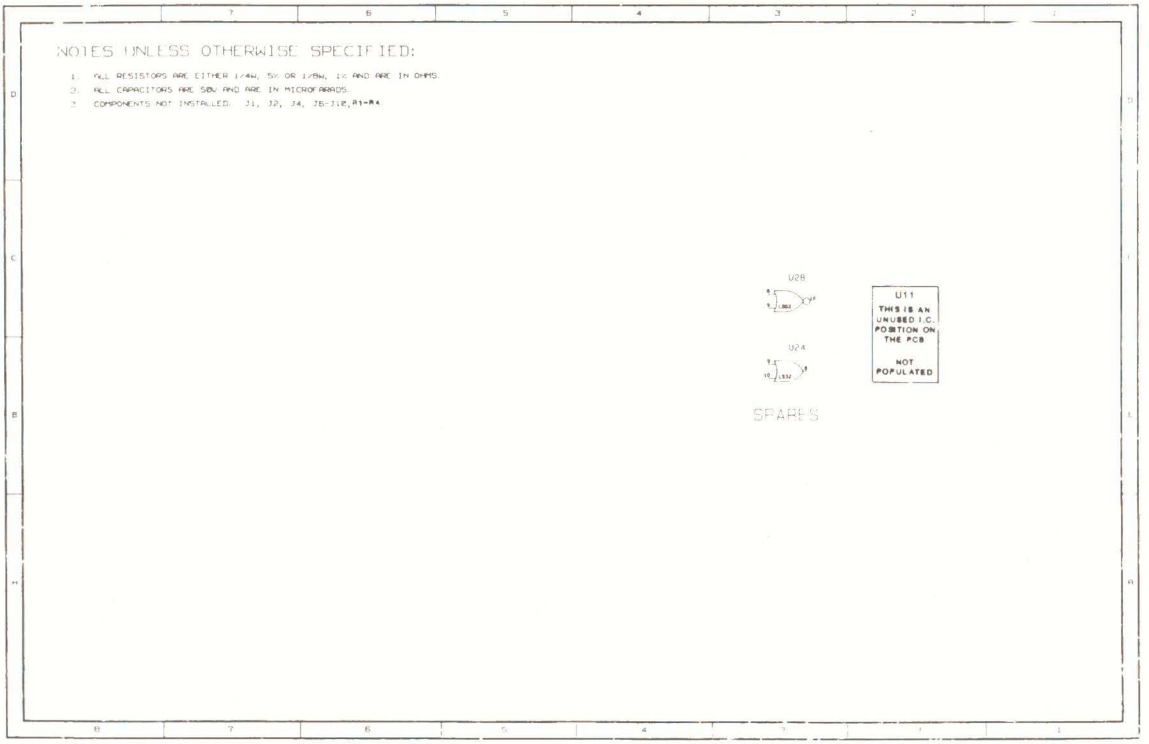

NOTES UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE EITHER 1/4W, 5% OR 1/8W, 1% AND ARE IN OHMS.
2. ALL CAPACITORS ARE 50V AND ARE IN MICROFARADS.
3. COMPONENTS NOT INSTALLED: J1, J2, J4, J6-J10, R1-R4.
U28
U24
SPARES
U11
THIS IS AN UNUSED I.C. POSITION ON THE PCB
NOT POPULATED

Figure 7-24. Video Display Controller Board Version 3 Schematics (Page 1 of 7)

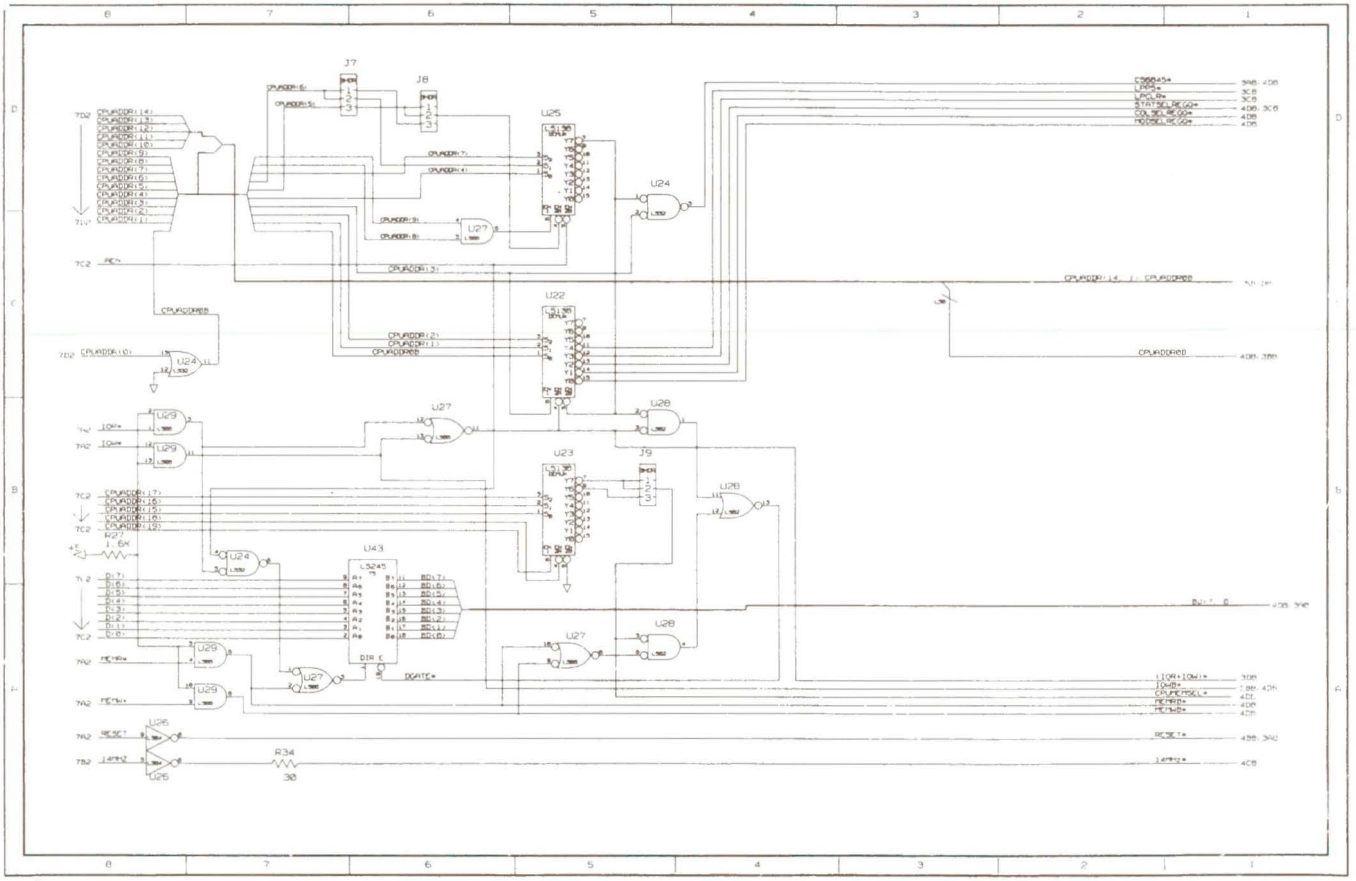


Figure 7-24. Video Display Controller Board Version 3 Schematics (Page 2 of 7)

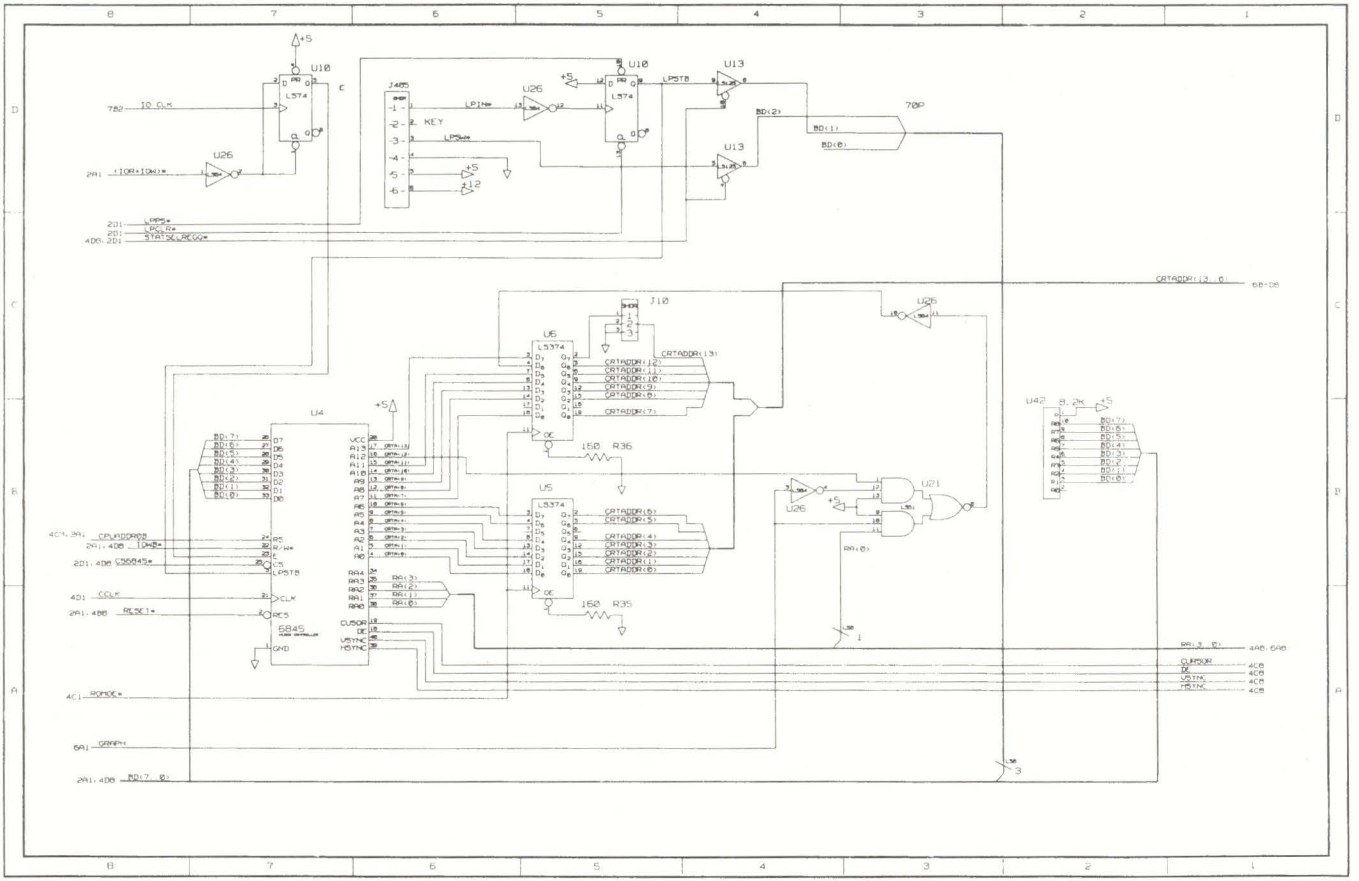


Figure 7-24. Video Display Controller Board Version 3 Schematics (Page 3 of 7)

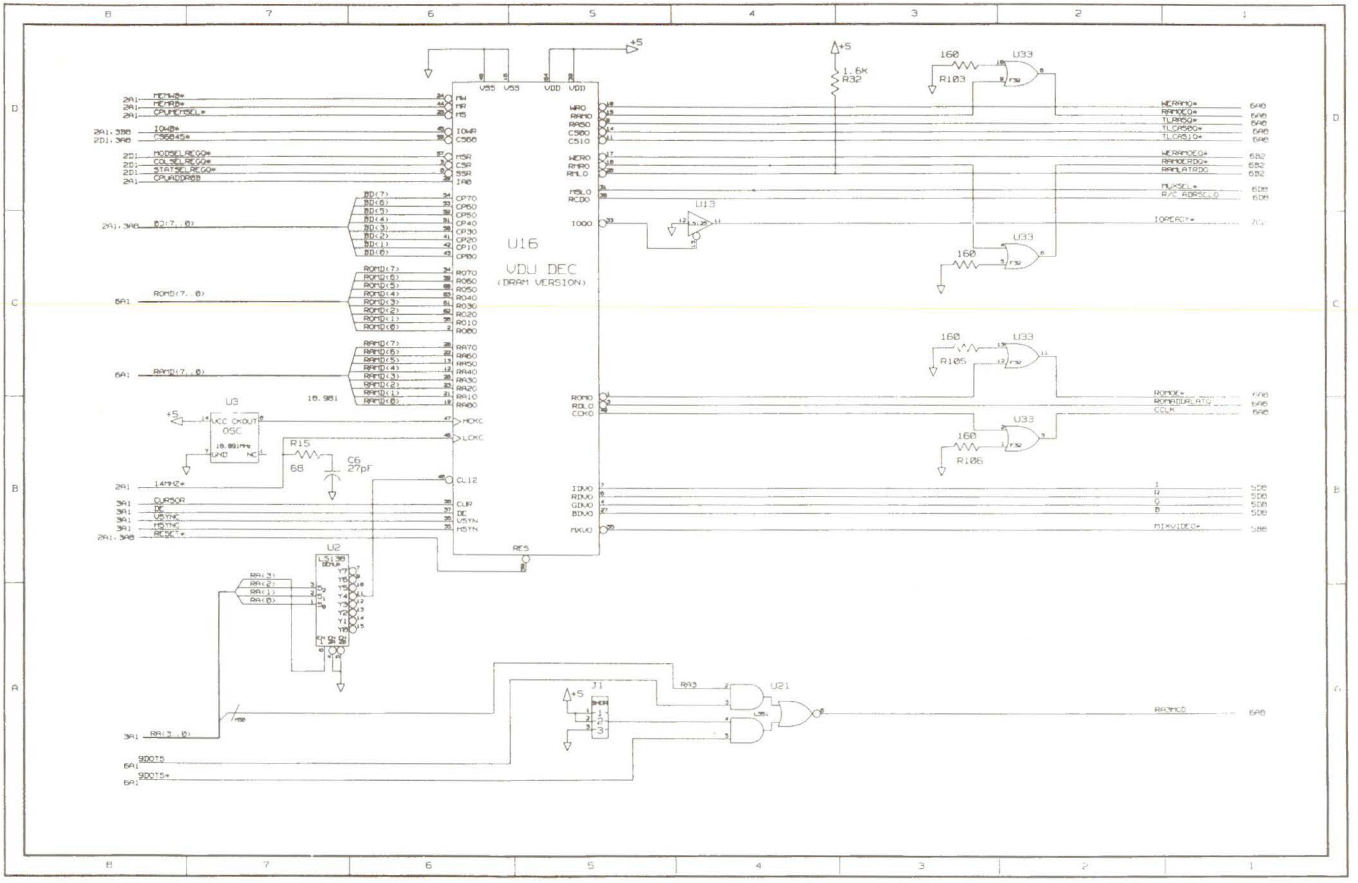


Figure 7-24. Video Display Controller Board Version 3 Schematics (Page 4 of 7)

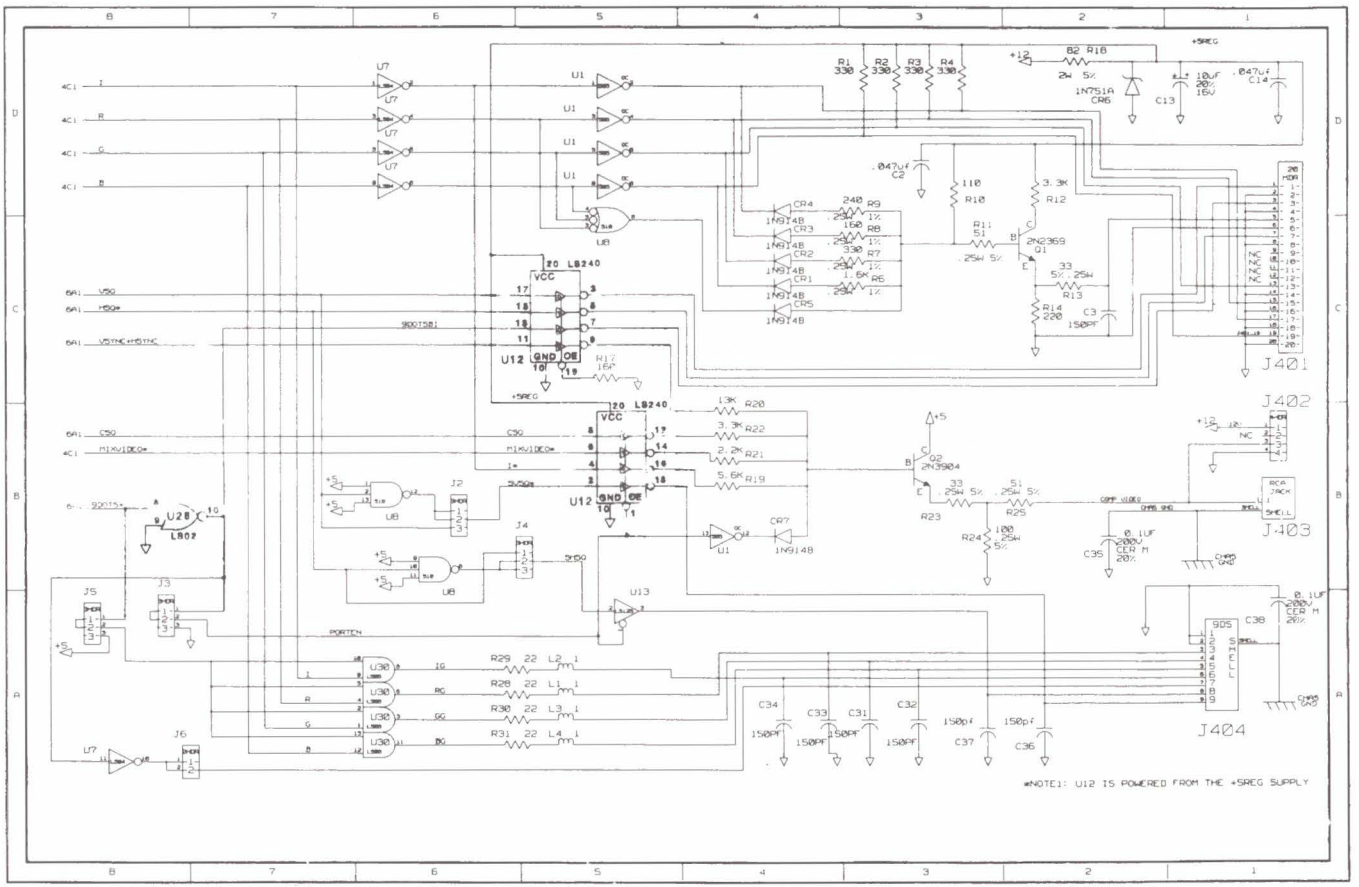


Figure 7-24. Video Display Controller Board Version 3 Schematics (Page 5 of 7)

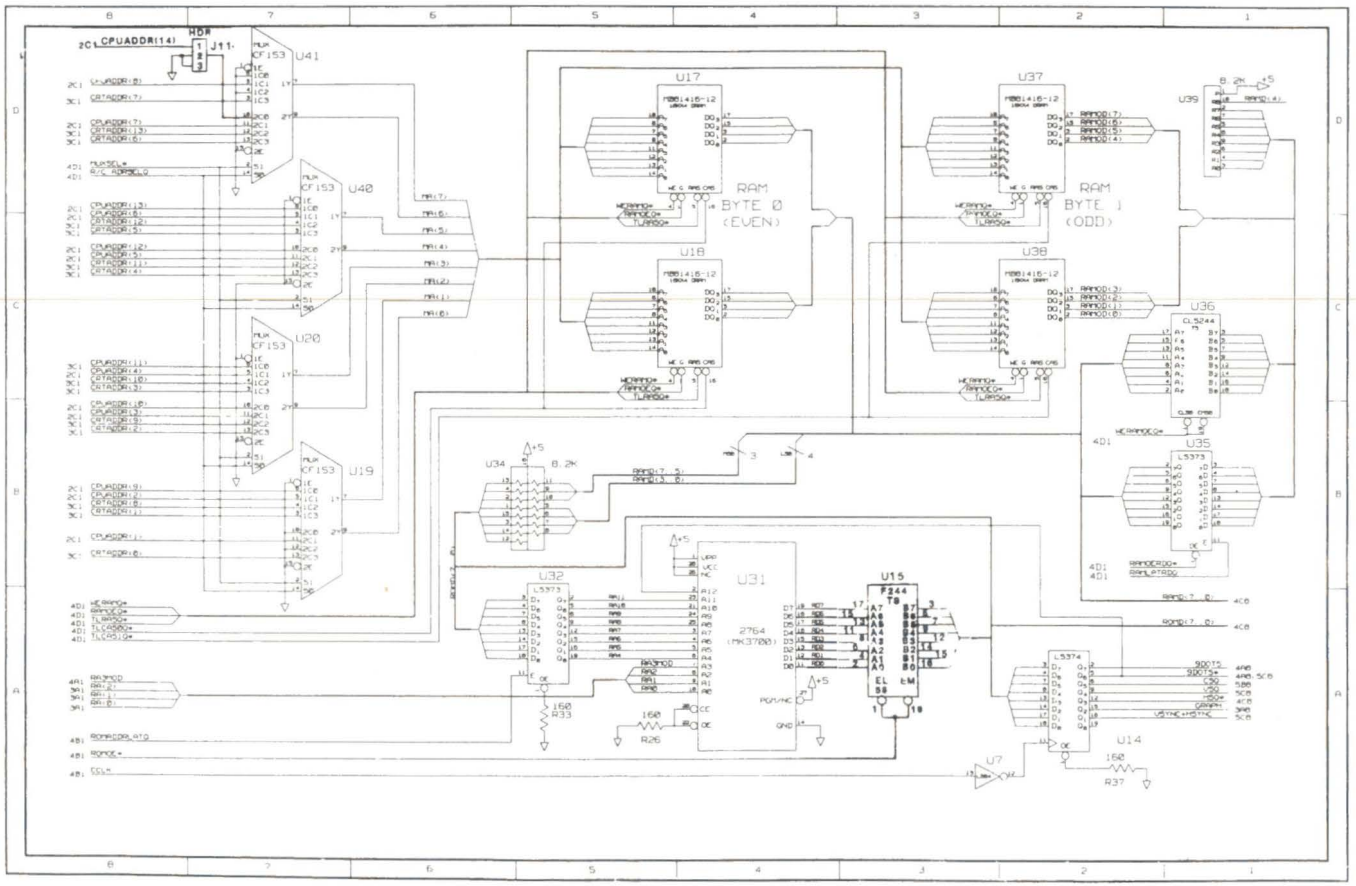


Figure 7-24. Video Display Controller Board Version 3 Schematics (Page 6 of 7)

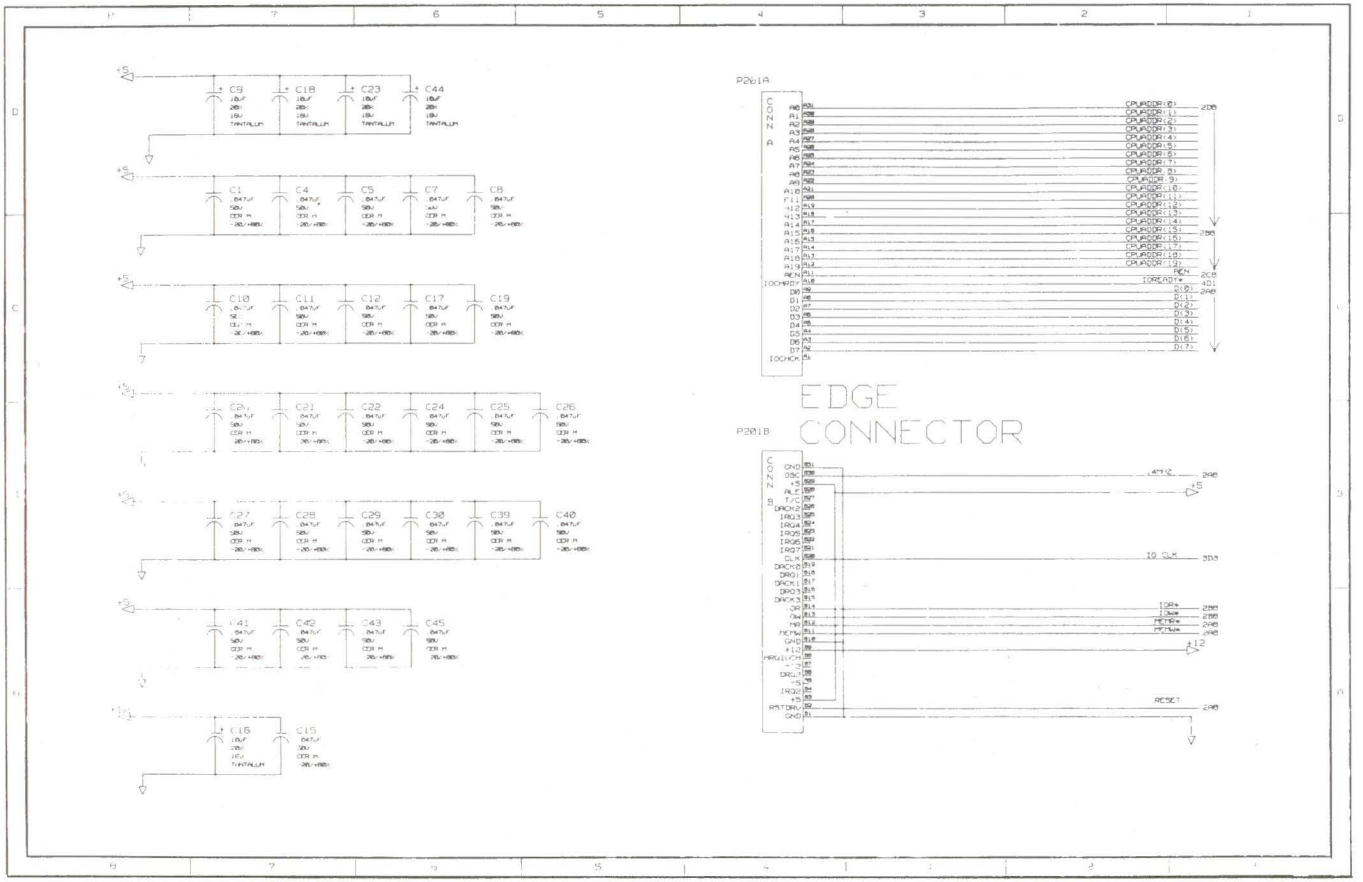


Figure 7-24. Video Display Controller Board Version 3 Schematics (Page 7 of 7)

Chapter 8
KEYBOARDS

Chapter 8
KEYBOARDS

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Chapter 8
KEYBOARDS

8.1 INTRODUCTION

The keyboard is the primary means by which the user communicates with the system. Two keyboards operate with the COMPAQ DESKPRO 286® : the 84-key keyboard and the COMPAQ Enhanced Keyboard. The COMPAQ® PORTABLE 286® uses only the 84-key keyboard. The COMPAQ Enhanced Keyboard is a 101-key keyboard (102 keys international) that offers additional features, such as a separate cursor control key cluster, additional function keys (F11 and F12), and enhanced programmability for make/break and repeating key functions.

Each of the two keyboards that operate with the COMPAQ DESKPRO 286 contains a microprocessor that scans the keyboard for pressed keys. The microprocessor also monitors its communication line with the system. The communication line carries keyboard control commands from the system and keyboard scan and acknowledgment codes to the system. Keyboard scan codes are generated by the keyboard when a key is pressed or released. Typically, a Make code is generated when a key is pressed. A Break code is generated when the key is released.

Within this chapter, the term "system" refers to the keyboard controller (8042) on the system board.

Figure 8-1 is a functional block diagram of the keyboard, which is the same for both keyboards.

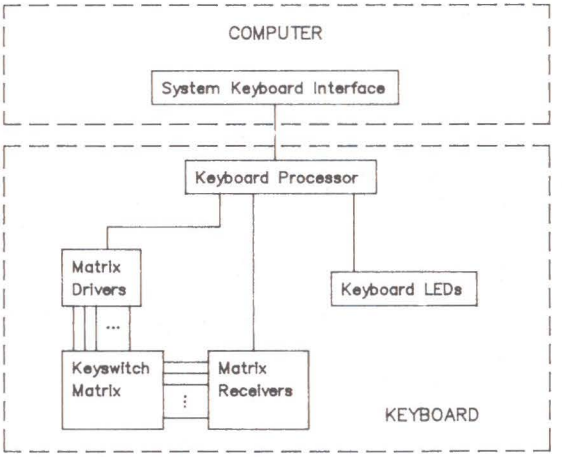


Figure 8-1. Keyboard Functional Block Diagram

8.2 KEYBOARD FEATURES

Both the 84-key and COMPAQ Enhanced keyboards contain a first-in, first-out (FIFO) buffer and a repeating key function. The 84-key keyboard can store as many as sixteen hex codes in its FIFO buffer. The COMPAQ Enhanced Keyboard is capable of storing sixteen 11-bit or twenty 9-bit hex codes in its FIFO buffer. Keycodes are placed in the FIFO buffer when keys are pressed or released, if the system is not ready to accept the keycode from the keyboard. When the system is ready to accept the keycode, the keyboard sends the keycodes stored in the FIFO buffer to the system in the order in which the keys were pressed.

When two keys are pressed simultaneously, the keyboard processes the first keycode detected and stores the second in the FIFO buffer. If any key is pressed while the FIFO buffer is full, the corresponding keycode is not generated and an overrun code (00h) is stored in the buffer. A location in the FIFO buffer is reserved for overrun conditions.

Another important feature of the keyboards is the repeating key function. This feature allows the keyboards to repeatedly generate and send the Make code to the system as long as the key is held down. The rate at which Make codes are generated can be programmed on both keyboards. The 84-key keyboard has a fixed set of keys (except for a few special function keys) that are capable of the repeat operation. The COMPAQ Enhanced Keyboard allows the user to designate a particular set of keys to perform the repeat operations. The set of keys that can perform the repeat operation is programmable by the system via commands.

Figure 8-2 shows the 84-key keyboard. Figure 8-3 shows the COMPAQ Enhanced Keyboard.

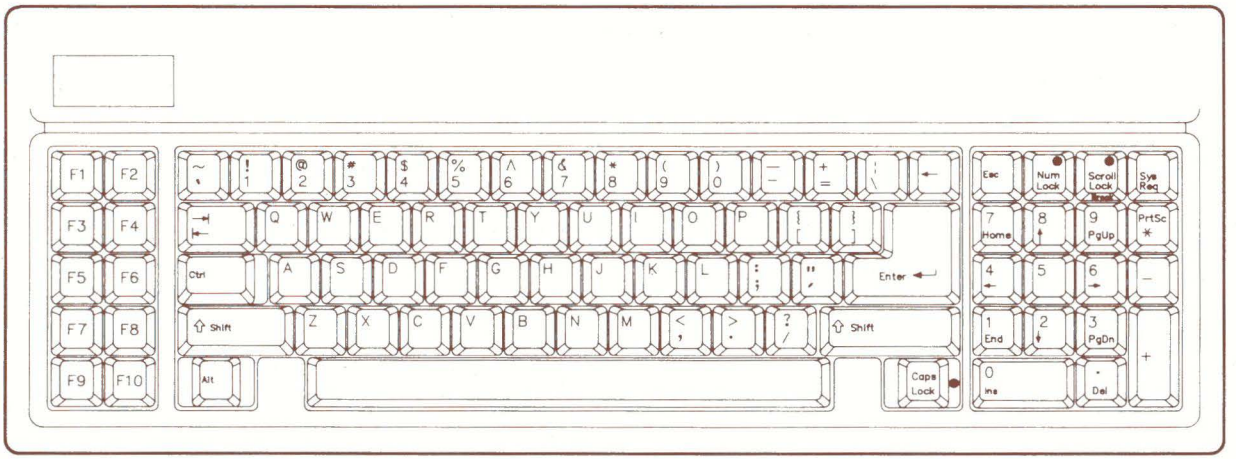


Figure 8-2. 84-Key Keyboard (U.S. English)

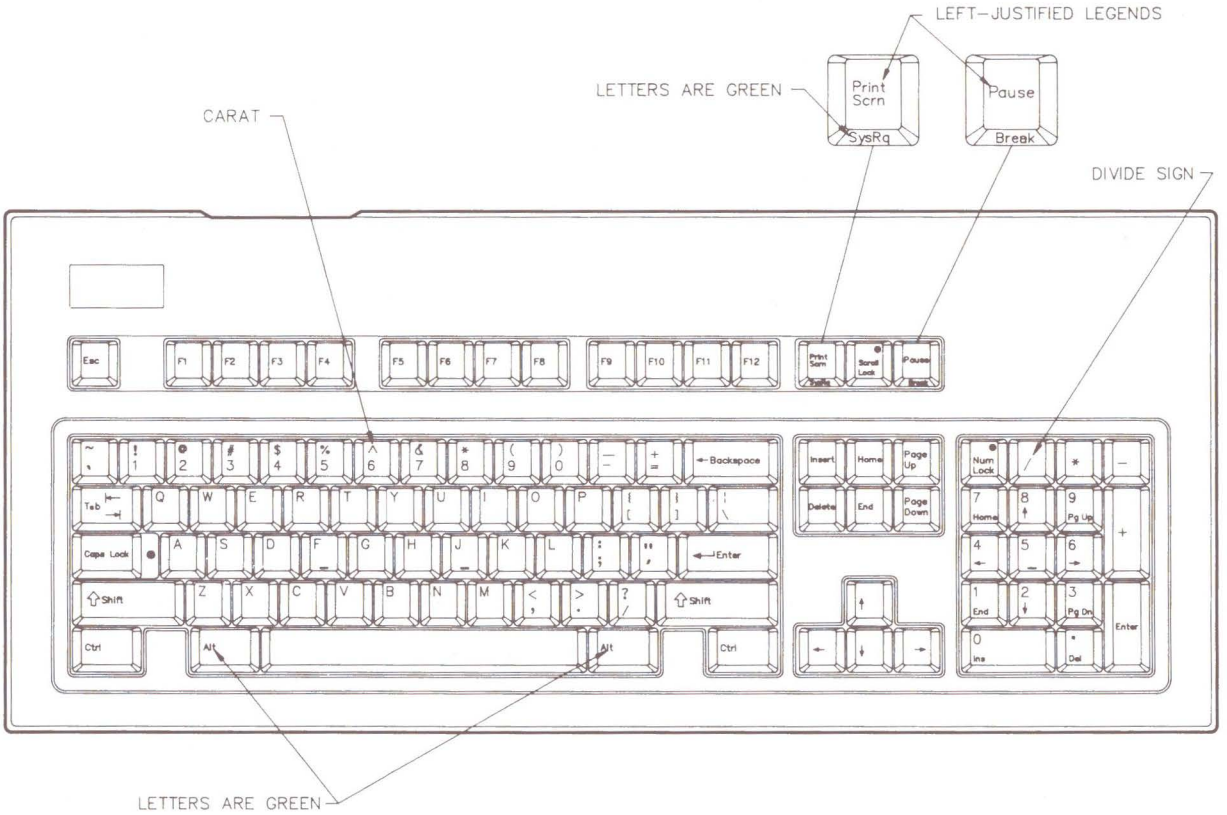


Figure 8-3. COMPAQ Enhanced Keyboard (U.S. English)

8.3 KEYBOARD COMMUNICATIONS INTERFACE

Both keyboards use a bidirectional, asynchronous interface for communications with the system. The keyboard cable is a 4-conductor, shielded cable.

The keyboard data (KBDDATA) and keyboard clock (KBDCLK) signals use TTL-compatible voltage levels, with open-collector drivers.

Communication between the system and the keyboards is implemented with a protocol method, shown in Figure 8-4.

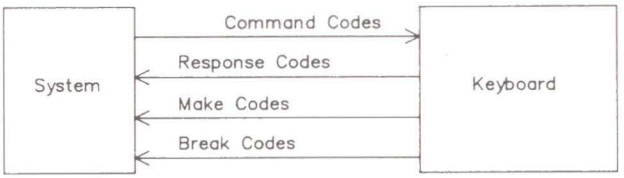


Figure 8-4. Keyboard Communication Protocol

Table 8-1. Keyboard Specifications for all Keyboards

	COMPAQ PORTABLE 286	COMPAQ DESKPRO 286
Voltage	+ 12 VDC	+ 5 VDC
Tolerance	± 15%	± 10%
Current	250 mA (maximum)	250 mA (maximum)
Cable Length:		
Coiled	20 in. (51 cm)	38 in. (97 cm)
Extended	57 in. (145 cm)	75 in. (190 cm)

Communication Protocol

The communications link between the system and keyboard is bidirectional. For status information, the system controls the communications link. For data communication, either the system or the keyboard can put data on the data line, but not at the same time. Clock pulses are always required to transfer data generated by the keyboard in either direction.

Commands from the System

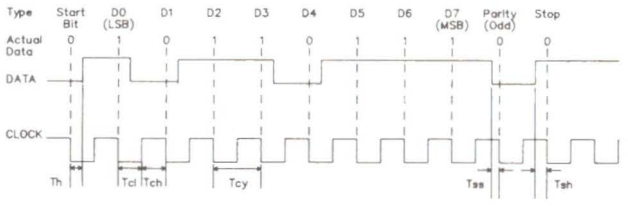
The system can send various commands to the keyboard. When the keyboard is transmitting data to the system, the system first clamps the CLOCK signal line to request a keyboard transmission halt. To ensure that the keyboard recognizes the system's request, the CLOCK line must remain low (0) for at least 60 us. If the keyboard's transmission is past the rising edge of the parity bit's CLOCK pulse, the keyboard completes its transmission before clocking in the system command. If the CLOCK line was clamped low prior to the rising edge of the parity bit clock pulse, the aborted transmission is loaded into the keyboard FIFO buffer.

When the system is ready to transmit a command to the keyboard, it sets the DATA line low (0). This action serves as both a Request-to-Send and a start bit. On detecting the DATA line low, the keyboard sets the CLOCK line low, causing the start bit to be clocked out of the system. The system then places the least-significant bit (LSB, data bit <0>) on the DATA line and the keyboard clocks this bit out of the system as shown in Figure 9-5. This process continues until all 8 data bits are clocked out of the system.

After all data bits are clocked out of the system, the system places an odd parity bit on the DATA line. The keyboard repeats its clocking of the parity bit as before. The keyboard then sets the DATA line low and clocks this line to the system for a stop bit. When the keyboard receives the stop bit, the system clamps the CLOCK line low to inhibit the keyboard while it is processing the received data.

After the keyboard receives a system command, the keyboard returns an ACK code to the system. If a parity error invalid code or time out occurs, a RESEND command is sent to the system. (For more information on the ACK code and RESEND, see the section titled "84-Key Keyboard Responses to the System" in this chapter.)

Figure 8-5 shows the timing of system-to-keyboard transmissions.



Code = EDh

Symbol	Parameter	Minimum	Maximum
Tcy	Cycle Time	60 us	80 us
Tcl	Clock Low	25 us	35 us
Tch	Clock High	25 us	45 us
Th	Data Hold	0 us	25 us
Tss	Stop Bit Setup	8 us	20 us
Tsh	Stop Bit Hold	15 us	25 us

Notes: 1. DATA signal clamped low by system, used as RTC signal.
2. DATA signal clamped low by keyboard as Stop Bit.
3. CLOCK signal clamped low by system to inhibit keyboard.

Figure 8-5. System-to-Keyboard Timing Transmissions

8.4 KEYBOARD FUNCTIONS

This section describes the unique functions of each keyboard. These descriptions refer to the U.S. keyboards only, because key numbers differ for the various international keyboards. The layouts of the international keyboards are illustrated in Section 8.6, International Keyboards.

84-Key Keyboard

The keyboard generates a fixed set of Make and Break codes for each of the keys on the 84-key keyboard. When a key is pressed, the keyboard sends that key's Make code to the system.

When a key is released, the keyboard sends two keycodes forming the Break Code: F0h, followed by that key's Make code to the system.

Figure 8-6 shows a layout of the 84-key keyboard and the position number assigned to each key. Table 8-2 lists the Make codes for each key on the 84-key

keyboard.

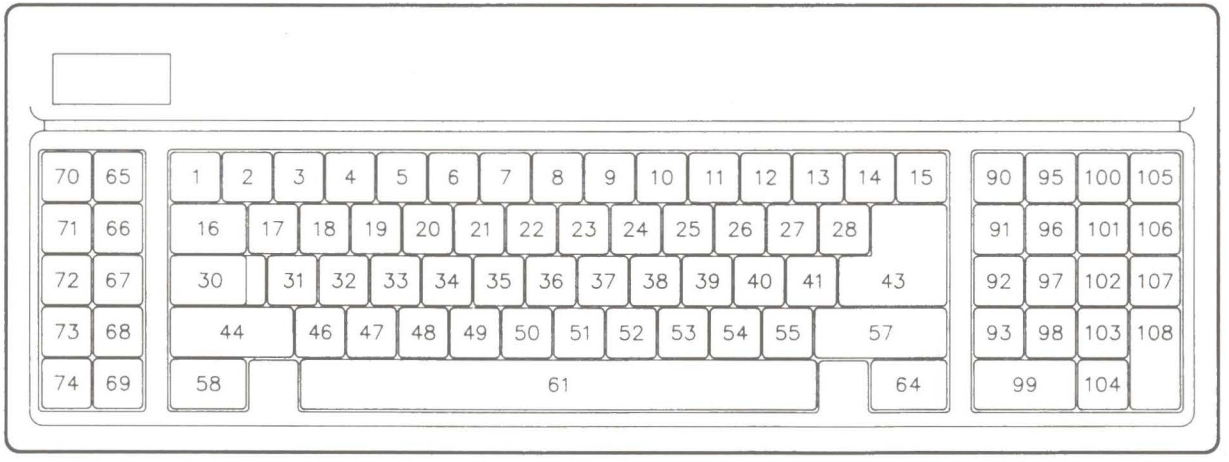


Figure 8-6. Assigned Position Number for Each Key on the 84-Key Keyboard

Table 8-2. Legend and Keycode Data for the U.S. 84-Key Keyboard

Location	Legend (Top of Cap)	Make Code
1	~ `	0E
2	! 1	16
3	@ 2	1E
4	# 3	26
5	$ 4	25
6	% 5	2E
7	^ 6	36
8	& 7	3D
9	* 8	3E
10	(9	46
11	) 0	45
12	_ -	4E
13	+ =	55
14	| \	5D
15	(BackSpace)	66
16	(Back Tab) (Tab)	0D
17	Q	15
18	W	1D
19	E	24
20	R	2D
21	T	2C
22	Y	35
23	U	3C
24	I	43
25	O	44

(Continued)

Table 8-2. (Continued)

Location	Legend (Top of Cap)	Make Code
26	P	4D
27	{ [	54
28	}]	5B
30	CTRL	14
31	A	1C
32	S	1B
33	D	23
34	F	2B
35	G	34
36	H	33
37	J	3B
38	K	42
39	L	4B
40	: ;	4C
41	" '	52
43	ENTER	5A
44	LEFT SHIFT	12
46	Z	1A
47	X	22
48	C	21
49	V	2A
50	B	32
51	N	31
52	M	3A
53	< ,	41

(Continued)

Table 8-2. (Continued)

Location	Legend (Top of Cap)	Make Code
54	> .	49
55	? /	4A
57	(Right) SHIFT	59
58	ALT	11
61	(Space Bar)	29
64	CAPS LOCK	58
65	F2	05
66	F4	06
67	F6	04
68	F8	0C
69	F10	03
70	F1	05
71	F3	04
72	F5	03
73	F7	83
74	F9	01
90	ESC	76
91	7 HOME	6C
92	4 (Left Arrow)	6B
93	1 END	69
95	NUM LOCK	77
96	8 (Up Arrow)	75
97	5	73
98	2 (Down Arrow)	72
99	0 INS	70

(Continued)

Table 8-2. (Continued)

Location	Legend (Top of Cap)	Make Code
100	SCROLL LOCK	7E
101	9 PGUP	7D
102	6 (Right Arrow)	74
103	3 PGDN	7A
104	. DEL	71
105	SYS REQ	84
106	PRINT SCREEN *	7C
107	-	7B
108	+	79

System/Keyboard Commands and Acknowledgments

The commands sent by the system are listed in Table 8-3.

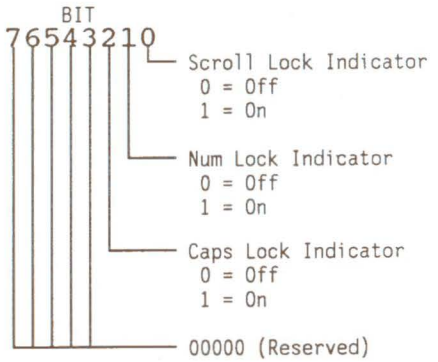
Table 8-3. System Commands to the Keyboard

Code	Function
EDh	Set Status Indicators
EEh	Echo Command (Diagnostic Aid)
EFh..F2h	Reserved--No operation
F3h	Set Key Repeat Rate
F4h	Enable the Keyboard
F5h	Disable Keyboard Scanning
F6h	Set Default Conditions
F7h..FDh	Reserved--No operation
FEh	Resend Command
FFh	Reset Command

SET STATUS INDICATORS (EDh)

The Set Status Indicators (EDh) command is a 2-byte command that changes the state of the keyboard LED indicators. After receiving this command, the keyboard halts scanning, returns an ACK (acknowledgment) code to the system, and waits for the system to send the option byte. The option byte indicates which LED indicators are to be affected.

When the option byte is received, the keyboard sets the status indicator, returns an ACK code, and resumes scanning if previously enabled. If another command is received while the keyboard is waiting for the option byte, the Set Status Indicators command is aborted and the new command is executed. No change to the LED indicators occurs. The status byte is formatted as follows:



Bit <7> is the most-significant bit (MSB), and bit <0> is the least-significant bit (LSB).

ECHO (EEh)

The Echo (EEh) command is used for diagnostics. After receiving this command, the keyboard returns an Echo (EEh) response.

NOP (EFh..F2h)

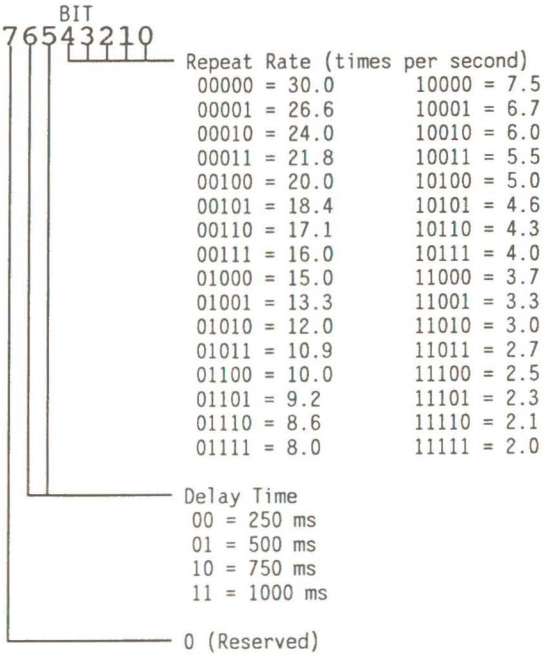
The keyboard responds to the NOP command with an ACK code. No other action is taken.

SET KEY REPEAT RATE (F3h)

The Set Key Repeat Rate (F3h) command is a 2-byte command that changes the key-repeat delay and rate values.

Once the keyboard receives the Set Key Repeat Rate command, it stops scanning and returns an ACK code. The system then sends a byte that contains the repeat rate and delay time values. The repeat rate is the number of times the key is repeated every second. The delay time is the length of time a key must be held down before the key repeat function begins. The keyboard then returns an ACK code and remains in the disabled state until it receives the Enable command.

The format for the Set Key Repeat Rate/Delay Time byte is as follows:



ENABLE (F4h)

The Enable (F4h) command causes the keyboard to start its scanning function. After receiving this command, the keyboard returns an ACK code, clears the output buffer, and starts scanning.

DISABLE (F5h)

The Disable (F5h) command halts keyboard scanning. After receiving this command, the keyboard returns an ACK (acknowledge) code to the system.

SET DEFAULT CONDITIONS (F6h)

The Set Default Conditions (F6h) command causes the keyboard to send an ACK code and its default conditions to the system. If the keyboard was enabled prior to receiving the Set Default Conditions command, the keyboard continues scanning.

NOP (F7h..FDh)

The keyboard responds to the NOP command with an ACK code. No other action is taken.

RESEND (FEh)

The Resend (FEh) command is issued to the keyboard only after a keyboard transmission. The keyboard responds by retransmitting the most recent byte transmitted to the system. If the most recent byte was Resend, the keyboard transmits the byte sent before the Resend command.

RESET (FFh)

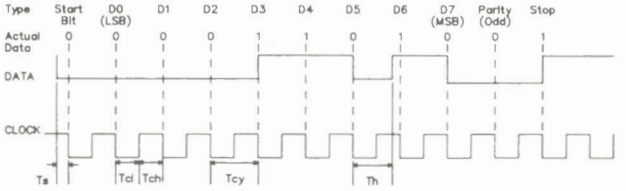
The Reset (FFh) command is accepted by the keyboard by returning an ACK code to the system. For the system to accept the ACK code, the system must raise the CLOCK and DATA lines for at least 500 us. After receiving the Reset command, the keyboard is disabled until either the ACK code is accepted by the system or another command is issued to the keyboard.

If the Reset ACK code is accepted by the system as described above, the keyboard clears its character output buffer, sets the default repeat-key rate, and turns all LED indicators ON, then OFF. Once this process is completed, an ACK code is sent to the system followed by a Power-on Complete response (an AAh code). At this point, the keyboard returns to normal operation.

84-Key Keyboard Responses to the System

Before the keyboard responses are sent to the system, the keyboard verifies the status of two signals, CLOCK and DATA. Should the CLOCK signal be low (=0), the keyboard recognizes an inhibited state and loads the keystrokes into its buffer as previously described. Once the inhibited state is removed, the keystrokes are sent to the system. If the data signal is low, the keyboard recognizes a Request-To-Send condition from the system. Keystrokes are also loaded into the keyboard buffer for this state and the keyboard prepares to receive the system commands. Once this state is cleared, the stored keystrokes are sent to the system.

The keyboard initiates the transmission of keystrokes and responses to system commands to the system only when both the CLOCK and DATA signals are high (=1). Data transmitted to the system consists of 11 bits: a start bit, 8 data bits, an odd parity bit, and a stop bit. Figure 8-7 shows the timing transmission for keyboard responses sent to the system.



Code = 58h

Symbol	Parameter	Minimum	Maximum
Tcy	Cycle Time	60 us	80 us
Tcl	Clock Low	30 us	35 us
Tch	Clock High	30 us	45 us
Ts	Data Setup	8 us	14 us
Th	Data Hold	45 us	62 us

Note: CLOCK signal clamped low by system to inhibit keyboard.

Figure 8-7. Timing Diagram Standard for Keyboard-to-System Transmissions

The system can halt a keyboard transmission by setting the CLOCK signal low. The keyboard checks the CLOCK signal every 60 us to verify the signal's state. If the CLOCK signal is detected as low, the keyboard finishes this transmission only if the rising edge of the CLOCK pulse for the parity bit has not occurred.

Responses sent from the keyboard to the system are listed in Table 8-4.

Table 8-4. Keyboard Responses to the System

Code	Function
00h	Overrun
AAh	Power-On Completed
EEh	Echo
F0h	Break
FAh	ACK
FEh	Resend
FDh	Failure

OVERRUN (00h)

The keyboard places 00h as the last character in the keyboard character buffer to indicate a buffer overrun.

POWER-ON COMPLETED (AAh)

The keyboard transmits the Power-On Completed (AAh) response to the system upon completion of power on and removal of the keyboard inhibit state, or on successful completion of a Reset command from the system.

ECHO (EEh)

The keyboard transmits an Echo response to the system in response to the system's Echo command. This response is substituted for the ACK code.

BREAK (F0h)

When a key is released, the keyboard transmits a Break prefix (F0h), followed by the Make code for that particular key.

ACK (FAh)

The keyboard transmits an ACK (FAh) code in response to valid system commands, except for an Echo or Resend command. If the command is not valid or had a parity error, the keyboard sends a Resend command to the system instead of an ACK. If the system begins a transmission during an ACK code response, the keyboard discards this ACK code and the new system command is accepted and processed.

RESEND (FEh)

The keyboard transmits a Resend (FEh) response to the system in response to an invalid system command. The Resend response instructs the system to retransmit its last command.

COMPAQ Enhanced Keyboard

The COMPAQ Enhanced Keyboard is capable of performing all the functions of the 84-key keyboard. It also supports a number of additional modes and functions. The most outstanding features are a separate cursor control key cluster and the addition of keys F11 and F12. Figure 8-8 shows a layout of the keyboard and the position number assigned to each key.

NOTE: Position numbers apply only to the U.S. English keyboard; position numbers are different for the international keyboard.

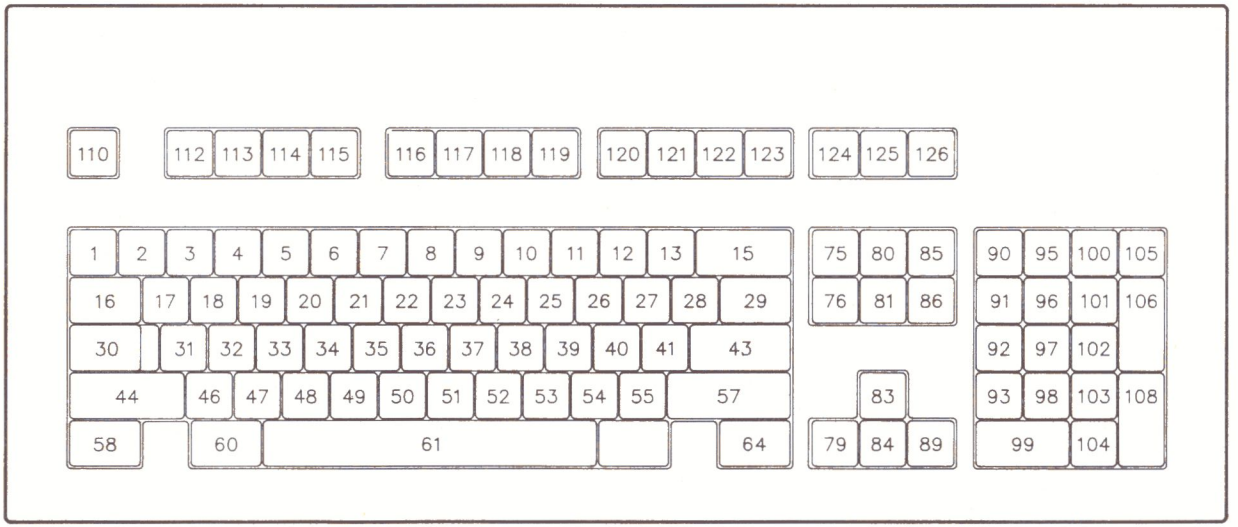


Figure 8-8. Assigned Position Number for Each Key on the COMPAQ Enhanced Keyboard

The COMPAQ Enhanced Keyboard has three operating modes. Each can be selected by using keyboard commands, which are discussed in more detail later in this section. These modes offer a range of functionality and compatibility features to software applications.

Mode 1

In Mode 1, the scan codes generated by the enhanced keyboard are compatible with keyboards used in 8088- and 8086-based systems. To access Mode 1 scan codes, send the F0h keyboard command to the keyboard and disable the 8042 scan code translation mapping. The scan codes generated by Mode 1 of the keyboard are identical to system codes required for input to the BIOS. To obtain system codes and status information, BIOS INT 16h functions AH = 00h, 01h, and 02h should be used by applications operating the keyboard in Mode 1.

Mode 2

In Mode 2, the COMPAQ Enhanced Keyboard generates scan codes compatible with the 84-key keyboard.

Mode 2 is the default mode of the COMPAQ Enhanced Keyboard that is selected by the COMPAQ DESKPRO 286 during power-on initialization. In this mode, the 8042 keyboard controller scan code translation is enabled so that the scan codes generated by the keyboard can be translated to the system codes required by the BIOS. Except for the system codes associated with the new keys of the COMPAQ Enhanced Keyboard, the system codes (after translation) resemble the scan codes generated by the keyboard in Mode 1. To properly access the system codes generated by the new keys of the COMPAQ Enhanced Keyboard, applications should use BIOS functions INT 16h AH = 10h, 11h, and 12h instead of the traditional functions INT 16h AH = 00h, 01h, and 02h. During power-on, NUM LOCK is set active to enable the numeric keypad.

Mode 3

Mode 3 generates a scan code set different from those of Modes 1 or 2. In this mode, the 8042 keyboard controller translation must be disabled, because the 8042 is not capable of translating the scan code set generated. Applications that want to use the COMPAQ Enhanced Keyboard in Mode 3 should explicitly select this mode by using the F0h keyboard command. These applications must assume responsibility for directly handling the scan codes generated by the keyboard since the 8042 and BIOS are not capable of handling the scan code set generated in Mode 3.

Tables 8-5 through 8-9 lists the scan code sets generated by the COMPAQ Enhanced Keyboard Modes 1, 2, and 3. For Mode 1, a Break code consists of a Make code with the high bit (bit <7>) set to 1. For example, 9Ch is the Break code for 1Ch, and A0h is the Break code for 20h. For Modes 2 and 3, a Break code is a 2-byte sequence consisting of the Make code immediately preceded by the F0h. For example, F0h 0Eh is the Break code for 0Eh.

In Modes 2 and 3, the COMPAQ Enhanced Keyboard generates the Break codes, F0h precedes the Make code to signify a Break code sequence. In Mode 1, the keyboard generates the Break codes by setting the most-significant bit of the Make code to a 1.

Table 8-5. COMPAQ Enhanced Keyboard Scan Codes for Mode 1

Key Location	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	Notes
1	`	29	
2	1	02	
3	2	03	
4	3	04	
5	4	05	
6	5	06	
7	6	07	
8	7	08	
9	8	09	
10	9	0A	
11	0	0B	
12	-	0C	
13	+	0D	
15	BACKSPACE	0E	
16	TAB	0F	
17	Q	10	
18	W	11	
19	E	12	

Notes: 1. Scan code refers to the code generated by the keyboard when a key is pressed. System code refers to the code input to the BIOS. Note that in Mode 1, the system codes are identical to the scan codes, because no translation is performed by the 8042 keyboard controller board.

2. All scan codes listed are for SHIFT, ALT, and CTRL inactive.

(Continued)

Table 8-5. (Continued)

Key Location	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	Notes
20	R	13	
21	T	14	
22	Y	15	
23	U	16	
24	I	17	
25	O	18	
26	P	19	
27	[	1A	
28	]	1B	
29	\	2B	
30	CAPS LOCK	3A	
31	A	1E	
32	S	1F	
33	D	20	
34	F	21	
35	G	22	
36	H	23	
37	J	24	
38	K	25	
39	L	26	
40	;	27	
41	"	28	
42		2B	(International only)
43	ENTER	1C	
44	(Left) SHIFT	2A	
45		56	(International only)

(Continued)

Table 8-5. (Continued)

Key Location	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	Notes
46	Z	2C	
47	X	2D	
48	C	2E	
49	V	2F	
50	B	30	
51	N	31	
52	M	32	
53	,	33	
54	.	34	
55	/	35	
57	(Right) SHIFT	36	
58	CTRL	1D	
60	(Left) ALT	38	
61	(Space Bar)	39	
62	(Right) ALT	E0 38	
64	(Right) CTRL	E0 1D	

Notes: 1. Scan code refers to the code generated by the keyboard when a key is pressed. System code refers to the code input to the BIOS. Note that in Mode 1, the system codes are identical to the scan codes, because no translation is performed by the 8042 keyboard controller.

2. All scan codes listed are for SHIFT, ALT, and CTRL inactive.

(Continued)

Table 8-5. (Continued)

Key Location	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	Notes
75	INS	E0 52	3
76	DEL	E0 53	3
79	(Left Arrow)	E0 4B	3
80	HOME	E0 47	3
81	END	E0 4F	3
83	(Up Arrow)	E0 48	3
84	(Down Arrow)	E0 50	3
85	PGUP	E0 49	3
86	PGDN	E0 51	3
89	(Right Arrow)	E0 4D	3
90	NUM LOCK	45	4
91	7	47	4
92	4	4B	4
93	1	4F	4
95	/	E0 35	4
96	8	48	4
97	5	4C	4
98	2	50	4
99	0	52	4
100	*	37	4
101	9	49	4
102	6	4D	4
103	3	51	4
104	.	53	4
105	-	4A	4
106	+	4E	4
108	ENTER	E0 1C	4

(Continued)

Table 8-5. (Continued)

Key Location	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	Notes
110	ESC	01	
112	F1	3B	
113	F2	3C	
114	F3	3D	
115	F4	3E	
116	F5	3F	
117	F6	40	
118	F7	41	
119	F8	42	
120	F9	43	
121	F10	44	
122	F11	57	
123	F12	58	
124	PRINT SCREEN	E0 2A E0 37	
125	SCROLL LOCK	46	
126	PAUSE	E1 1D 45 E1 9D C5	

Notes:
1. Scan code refers to the code generated by the keyboard when a key is pressed. System code refers to the code input to the BIOS. Note that in Mode 1, the system codes are identical to the scan codes, because no translation is performed by the 8042 keyboard controller.
2. All scan codes listed are for SHIFT, ALT, and CTRL inactive.
3. Scan codes listed are for NUM LOCK inactive.
4. This is a numeric cluster key.

The following keys have special codes during Mode 1 operation depending on the state of the SHIFT, NUM LOCK, ALT, and CTRL keys. Table 8-6 lists the scan codes generated by these keys.

Table 8-6. Combination Scan Codes for Mode 1

Key Location	U.S. Key Legend	Scan Code Make/Break
Shift Active with NUM LOCK OFF:		
75	INS	E0 AA E0 52
76	DEL	E0 AA E0 53
79	(Left Arrow)	E0 AA E0 4B
80	HOME	E0 AA E0 47
81	END	E0 AA E0 4F
83	(Up Arrow)	E0 AA E0 48
84	(Down Arrow)	E0 AA E0 50
85	PGUP	E0 AA E0 49
86	PGDN	E0 AA E0 51
89	(Right Arrow)	E0 AA E0 4D
Shift Active with NUM LOCK ON:		
75	INS	E0 52
76	DEL	E0 53
79	(Left Arrow)	E0 4B
80	HOME	E0 47
81	END	E0 4F
83	(Up Arrow)	E0 48
84	(Down Arrow)	E0 50
85	PGUP	E0 49
86	PGDN	E0 51
89	(Right Arrow)	E0 4D
95	KEYPAD /	E0 35/E0 B5
Shift Active or CTRL Active:		
124	PRINT SCREEN	E0 37 / E0 B7
ALT Active:		
124	PRINT SCREEN	54 / D4
CTRL Active:		
126	PAUSE	E0 46 E0 C6

Note: Key 126 is not typematic and generates a scan code only on the Make condition.

Table 8-7. COMPAQ Enhanced Keyboard Scan Codes for Mode 2

Key Code	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	System Code (hex)	Note
1	`	0E	29	
2	1	16	02	
3	2	1E	03	
4	3	26	04	
5	4	25	05	
6	5	2E	06	
7	6	36	07	
8	7	3D	08	
9	8	3E	09	
10	9	46	0A	
11	0	45	0B	
12	-	4E	0C	
13	+	55	0D	
15	BACKSPACE	66	0E	
16	TAB	0D	0F	
17	Q	15	10	
18	W	1D	11	
19	E	24	12	
20	R	2D	13	
21	T	2C	14	
22	Y	35	15	
23	U	3C	16	
24	I	43	17	
25	O	44	18	
26	P	4D	19	
27	[	54	1A	
28	]	5B	1B	

(Continued)

Table 8-7. (Continued)

Key Code	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	System Code (hex)	Note
29	\	5D	2B	
30	CAPS LOCK	58	3A	
31	A	1C	1E	
32	S	1B	1F	
33	D	23	20	
34	F	2B	21	
35	G	34	22	
36	H	33	23	
37	J	3B	24	
38	K	42	25	
39	L	4B	26	
40	;	4C	27	
41	"	52	28	
42		5D	(International only)	
43	ENTER	5A	1C	
44	(Left) SHIFT	12	2A	
45		61	(International only)	

Notes:
1. Scan code refers to the code generated by the keyboard when a key is pressed. The system code is the code as translated by the 8042 keyboard controller and input to the BIOS.
2. All scan codes listed are for SHIFT, ALT, and CTRL inactive.

(Continued)

Table 8-7. (Continued)

Key Code	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	System Code (hex)	Note
46	Z	1A	2C	
47	X	22	2D	
48	C	21	2E	
49	V	2A	2F	
50	B	32	30	
51	N	31	31	
52	M	3A	32	
53	,	41	33	
54	.	49	34	
55	/	4A	35	
57	(Right) SHIFT	59	36	
58	(Left) CTRL	14	1D	
60	(Left) ALT	11	38	
61	(Space)	29	39	
62	(Right) ALT	E0 11	E0 38	
64	(Right) CTRL	E0 14	E0 1D	
75	INS	E0 70	E0 52	3
76	DEL	E0 71	E0 53	3
79	(Left Arrow)	E0 6B	E0 4B	3
80	HOME	E0 6C	E0 47	3
81	END	E0 69	E0 4F	3
83	(Up Arrow)	E0 75	E0 48	3
84	(Down Arrow)	E0 72	E0 50	3
85	PGUP	E0 7D	E0 49	3
86	PGDN	E0 7A	E0 51	3
89	(Right Arrow)	E0 74	E0 4D	3
90	NUM LOCK	77	45	4
91	7	6C	47	4

(Continued)

Table 8-7. (Continued)

Key Code	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	System Code (hex)	Note
92	4	6B	4B	4
93	1	69	4F	4
95	/	E0 4A	E0 35	4
96	8	75	48	4
97	5	73	4C	4
98	2	72	50	4
99	0	70	52	4
100	*	7C	37	4
101	9	7D	49	4
102	6	74	4D	4
103	3	7A	51	4
104	.	71	53	4
105	-	7B	4A	4
106	+	79	4E	4
108	ENTER	E0 5A	E0 1C	4
110	ESC	76	01	
112	F1	05	3B	
113	F2	06	3C	

Notes:
1. Scan code refers to the code generated by the keyboard when a key is pressed. The system code is the code as translated by the 8042 keyboard controller and input to the BIOS.
2. All scan codes listed are for SHIFT, ALT, and CTRL inactive.
3. Scan codes listed are for NUM LOCK inactive.
4. This is a numeric cluster key.

(Continued)

Table 8-7. (Continued)

Key Code	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	System Code (hex)	Note
114	F3	04	3D	
115	F4	0C	3E	
116	F5	03	3F	
117	F6	0B	40	
118	F7	83	41	
119	F8	0A	42	
120	F9	01	43	
121	F10	09	44	
122	F11	78	57	
123	F12	07	58	
124	PRINT SCREEN	E0 12 E0 7C	E0 2A E0 37	
125	SCROLL LOCK	7E	46	
126	PAUSE	E1 14 77 E1 F0 14 F0 77	E1 1D 45 E1 9D C5	

Notes:
1. Scan code refers to the code generated by the keyboard when a key is pressed. The system code is the code as translated by the 8042 keyboard controller and input to the BIOS.
2. All scan codes listed are for SHIFT, ALT, and CTRL inactive.
3. Scan codes listed are for NUM LOCK inactive.
4. This is a numeric cluster key.

Combination scan codes for Mode 2 are the same as for Mode 1. Refer to Table 8-6 for the combination scan codes.

The following keys have special codes during Mode 2 operation depending on the state of the SHIFT, NUM LOCK, ALT, and CTRL keys. Table 8-8 lists the scan codes generated by these keys.

Table 8-8. Combination Scan Codes for Mode 2

Key Location	U.S. Key Legend	Scan Code
Shift Active with NUM LOCK OFF:		
75	INS	E0 F0 12 E0 70
76	DEL	E0 F0 12 E0 71
79	(Left Arrow)	E0 F0 12 E0 6B
80	HOME	E0 F0 12 E0 6C
81	END	E0 F0 12 E0 69
83	(Up Arrow)	E0 F0 12 E0 75
84	(Down Arrow)	E0 F0 12 E0 72
85	PGUP	E0 F0 12 E0 7D
86	PGDN	E0 F0 12 E0 7A
89	(Right Arrow)	E0 F0 12 E0 74
Shift Inactive with NUM LOCK ON:		
75	INS	E0 12 E0 70
76	DEL	E0 12 E0 71
79	(Left Arrow)	E0 12 E0 6B
80	HOME	E0 12 E0 6C
81	END	E0 12 E0 69
83	(Up Arrow)	E0 12 E0 75
84	(Down Arrow)	E0 12 E0 72
85	PGUP	E0 12 E0 7D
86	PGDN	E0 12 E0 7A
89	(Right Arrow)	E0 12 E0 74
Shift Active with NUM LOCK OFF:		
95	Keypad /	E0 F0 12 4A

(Continued)

Table 8-8. (Continued)

Key Location	U.S. Key Legend	Scan Code
Shift Active or CTRL Active:		
124	PRINT SCREEN	E0 7C
ALT Active:		
124	PRINT SCREEN	84
CTRL Active:		
126	PAUSE	E0 7E E0 F0 7E

Note: Key 126 is not a repeat key and generates a scan code only on the Make condition.

Table 8-9. COMPAQ Enhanced Keyboard Scan Codes for Mode 3

Key Code	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	Note
1		0E	
2	1	16	
3	2	1E	
4	3	26	
5	4	25	
6	5	2E	
7	6	36	
8	7	3D	
9	8	3E	
10	9	46	
11	0	45	
12	-	4E	
13	+	55	
15	BACKSPACE	66	
16	TAB	0D	
17	Q	15	
18	W	1D	

Notes:
1. Scan code refers to the code generated by the keyboard when a key is pressed. No system code is shown in this mode, because in keyboard Mode 3 the 8042 keyboard controller scan code translation should be disabled. The application should directly handle all scan codes as generated by the keyboard.
2. All scan codes listed are for SHIFT, ALT, and CTRL inactive.

(Continued)

Table 8-9. (Continued)

Key Code	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	Note
19	E	24	
20	R	2D	
21	T	2C	
22	Y	35	
23	U	3C	
24	I	43	
25	O	44	
26	P	4D	
27	[	54	
28	]	5B	
29	\	5C	
30	CAPS LOCK	14	
31	A	1C	
32	S	1B	
33	D	23	
34	F	2B	
35	G	34	
36	H	33	
37	J	3B	
38	K	42	
39	L	4B	
40	;	4C	
41	"	52	
42		53	(International only)
43	ENTER	5A	
44	(Left) SHIFT	12	
45		13	(International only)

(Continued)

Table 8-9. (Continued)

Key Code	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	Note
46	Z	1A	
47	X	22	
48	C	21	
49	V	2A	
50	B	32	
51	N	31	
52	M	3A	
53	,	41	
54	.	49	
55	/	4A	
57	(Right) SHIFT	59	
58	(Left) CTRL	11	
60	(Left) ALT	19	
61	(Space Bar)	29	
62	(Right) ALT	39	
64	(Right) CTRL	58	
75	INS	67	
76	DEL	64	

Notes:
1. Scan code refers to the code generated by the keyboard when a key is pressed. No system code is shown in this mode, because in keyboard Mode 3 the 8042 keyboard controller scan code translation should be disabled. The application should directly handle all scan codes as generated by the keyboard.
2. All scan codes listed are for SHIFT, ALT, and CTRL inactive.

(Continued)

Table 8-9. (Continued)

Key Code	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	Notes
79	(Left Arrow)	61	
80	HOME	6E	
81	END	65	
83	(Up Arrow)	63	
84	(Down Arrow)	60	
85	PGUP	6F	
86	PGDN	6D	
89	(Right Arrow)	6A	
90	NUM LOCK	76	3
91	7	6C	3
92	4	6B	3
93	1	69	3
95	/	77	3
96	8	75	3
97	5	73	3
98	2	72	3
99	0	70	3
100	*	7E	3
101	9	7D	3
102	6	74	3
103	3	7A	3
104	.	71	3
105	-	84	3
106	+	7C	3

(Continued)

Table 8-9. (Continued)

Key Code	U.S. Key Cap Legend	Scan Code (hex) (Notes 1, 2)	Notes
108	ENTER	79	3
110	ESC	08	
112	F1	07	
113	F2	0F	
114	F3	17	
115	F4	1F	
116	F5	27	
117	F6	2F	
118	F7	37	
119	F8	3F	
120	F9	47	
121	F10	4F	
122	F11	56	
123	F12	5E	
124	PRINT SCREEN	57	
125	SCROLL LOCK	5F	
126	PAUSE	62	

Notes:
1. Scan code refers to the code generated by the keyboard when a key is pressed. No system code is shown in this mode, because in keyboard Mode 3 the 8042 keyboard controller scan code translation should be disabled. The application should directly handle all scan codes as generated by the keyboard.
2. All scan codes listed are for SHIFT, ALT, and CTRL inactive.
3. This is a numeric cluster key.

In addition to the commands supported by the 84-key keyboard, the COMPAQ Enhanced Keyboard supports a number of commands related to its enhanced programmable functions. Table 8-10 lists the additional commands supported by the COMPAQ Enhanced Keyboard.

Table 8-10. Additional Commands Supported by the COMPAQ Enhanced Keyboard

Command Code	Function
F2h	Requests the identification sequence from the keyboard. The keyboard should respond with an ACK and the 2-byte identification code. The enhanced keyboard identification sequence is ABh followed by 83h. The keyboard scanning is then enabled.
EFh, F1h	Keyboard does not acknowledge these commands. The keyboard transmits a Resend response and continues scanning for keys.
F0h	Selects one of three modes of operation for the COMPAQ Enhanced Keyboard. This is a 2-byte command sequence. The second byte specifies the mode of the COMPAQ Enhanced Keyboard. The second byte is as follows: 01 - Selects Mode 1 of the keyboard. 02 - Selects Mode 2 of the keyboard. 03 - Selects Mode 3 of the keyboard. Once the option byte is acknowledged, the keyboard establishes the new mode of operation and resumes scanning.
F3h	Programs the typematic rate and delay. This is a 2-byte command sequence. The second byte specifies the typematic rate and delay. The second byte is as follows: Bit 7 - Always 0 Bits 6,5 - Delay (00 = 250 ms, 01 = 500 ms, 10 = 750 ms, 11 = 1000 ms) Bits 4,3,2,1,0 - Typematic rate (00000 = 30.0 cps, 00001 = 26.7 cps, 00010 = 24.0 cps, 00011 = 21.8 cps, 00100 = 20.0 cps, 00101 = 18.5 cps, 00110 = 17.1 cps, 00111 = 16.0 cps, 01000 = 15.0 cps, 01001 = 13.3 cps, 01010 = 12.0 cps, 01011 = 10.9 cps, 01100 = 10.0 cps, 01101 = 9.2 cps, 01110 = 8.6 cps, 01111 = 8.0 cps, 10000 = 7.5 cps, 10001 = 6.7 cps, 10010 = 6.0 cps, 10011 = 5.5 cps, 10100 = 5.0 cps, 10101 = 4.6 cps, 10110 = 4.3 cps, 10111 = 4.0 cps, 11000 = 3.7 cps, 11001 = 3.3 cps, 11010 = 3.0 cps, 11011 = 2.7 cps, 11100 = 2.5 cps, 11101 = 2.3 cps, 11110 = 2.1 cps, 11111 = 2.0 cps)
F4h	Enables the keyboard. Keyboard scanning is enabled.
F5h	Disables the keyboard. Keyboard scanning is disabled.
F6h	Sets all keys to their power-on values. Once the keyboard acknowledges the command, it resumes scanning if previously enabled.

(Continued)

Table 8-10. (Continued)

Command Code	Function
F7h	Programs all keys to be able to perform the repeat function. Once the keyboard acknowledges the command, it resumes scanning if previously enabled. This command is enabled only during the Mode 3 keyboard operation.
F8h	Programs all keys to generate Make/Break codes. Once the keyboard acknowledges the command, it resumes scanning if previously enabled. This command is enabled only during Mode 3 keyboard operation.
F9h	Programs all keys to generate only Make codes. Once the keyboard acknowledges the command, it resumes scanning if previously enabled. This command is enabled only during Mode 3 keyboard operation.
FAh	Programs all keys for Make/Break and repeat operations. Once the keyboard acknowledges the command, it resumes scanning if previously enabled. This command is enabled only during Mode 3 keyboard operation.
FBh	Enables the repeat function of an individual key. A 2-byte command, of which the second byte is the Make code, it identifies the key to be affected by the command. This command is enabled only during Mode 3 keyboard operation. Keyboard scanning is disabled after this command. An Enable (F4h) command allows the keyboard to resume scanning.

(Continued)

Table 8-10. (Continued)

Command Code	Function
FCh	Programs an individual key to generate Make and Break codes. A 2-byte command, of which the second byte is the Make code, it identifies the key to be affected by the command. This command is enabled only during Mode 3 keyboard operation. Keyboard scanning is disabled after this command. An Enable (F4h) command allows the keyboard to resume scanning.
FDh	Programs an individual key to generate only Make codes. A 2-byte command, of which the second byte is the Make code, it identifies the key to be affected by the command. This command is enabled only during Mode 3 keyboard operation. Keyboard scanning is disabled after this command. An Enable (F4h) command allows the keyboard to resume scanning.
F5h	Disables the keyboard from the system. The keyboard acknowledges the command and resets to the following conditions: ■ Resets typematic rate to 10 characters per second ■ Sets typematic delay to 500 ms ■ Halts scanning ■ Clears keyboard buffer ■ Sets default key types (Mode 3 only) ■ Clears last typematic key ■ Awaits further system instructions

(Continued)

Table 8-10. (Continued)

Command Code	Function
F6h	The keyboard resets to the following conditions: ■ Resets typematic rate to 10 characters per second ■ Sets typematic delay to 500 ms ■ Clears keyboard buffer ■ Sets default key types (Mode 3 only) ■ Clears last typematic key ■ Continues to scan

Figure 8-9 shows the key legends associated with key 42 for the international COMPAQ Enhanced Keyboards. Figure 8-10 shows the legends for key 45. Table 8-11 lists the scan codes for these keys.

Table 8-11. International Scan Codes

Key	Mode 1 Scan Code (h)	Mode 2 Scan Code (h)	Mode 3 Scan Code (h)
42	2B	5D	53
45	56	61	13

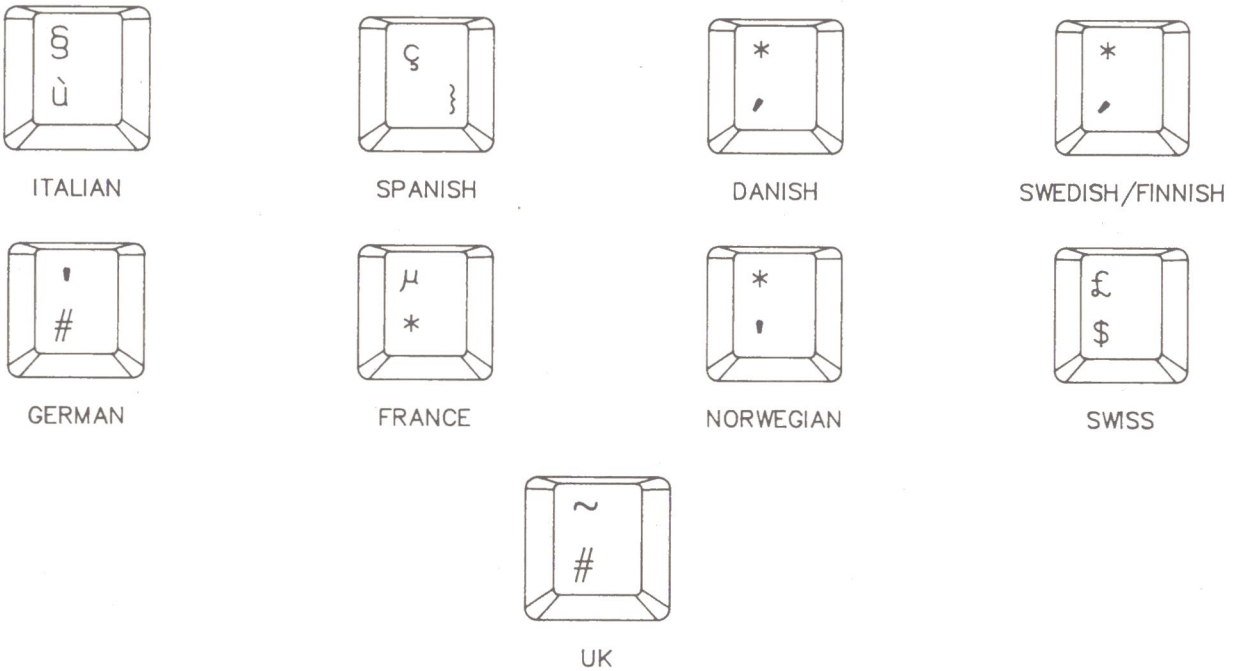


Figure 8-9. Key 42

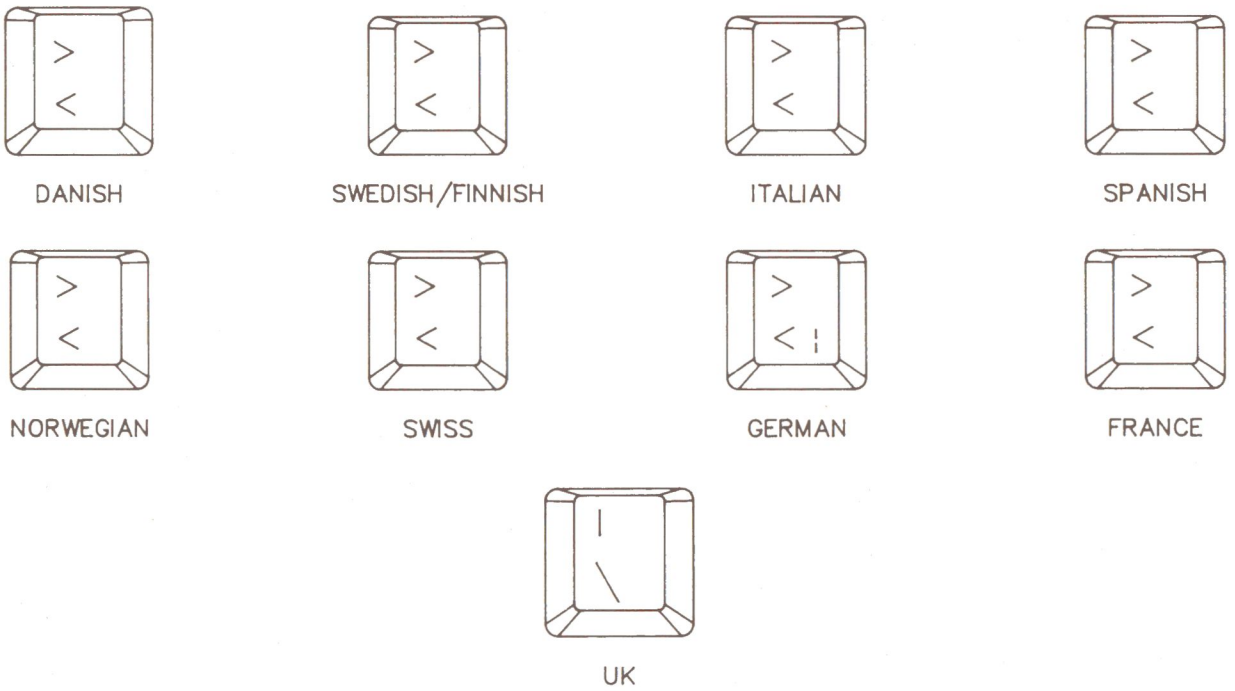


Figure 8-10. Key 45

8.5 CONNECTORS

The keyboard for the COMPAQ PORTABLE 286 uses a 6-pin modular-type connector, which is shown in Figure 8-11.

Both keyboards for the COMPAQ DESKPRO 286 use a 5-pin molded connector, which is shown in Figure 8-12.

Table 8-12 lists the keyboard connector signals.

Table 8-12. Keyboard Cable Connector Signals

COMPAQ DESKPRO 286 Pin	Signal
1	KBDCLK (Keyboard Clock Signal)
2	KBDDATA (Keyboard Data Signal)
3	Reserved (Note 1)
4	Signal Ground
5	Power (Note 2)
Shield	Chassis Ground

Notes:
1. Pin 3 on the COMPAQ PORTABLE 286 keyboard connector is +5 VDC.
2. Power for the COMPAQ PORTABLE 286 is +12 VDC. Power for the COMPAQ DESKPRO 286 is +5 VDC.

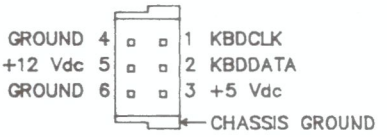


Figure 8-11. COMPAQ PORTABLE 286 Keyboard Connector

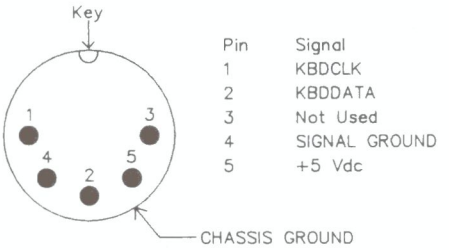


Figure 8-12. COMPAQ DESKPRO 286 Keyboard Connector

8.6 INTERNATIONAL KEYBOARDS

This section shows the international versions of the COMPAQ Enhanced Keyboard and the 84-key keyboard. Figures 8-13 through 8-22 show the version by country in alphabetic order.

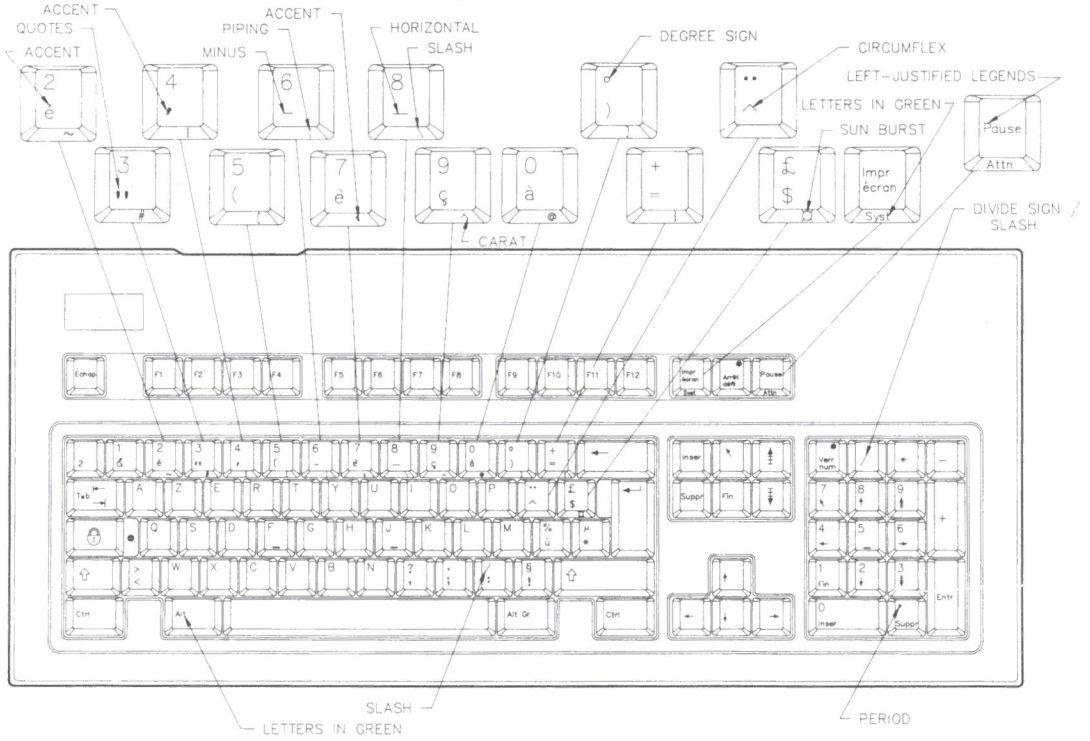


Figure 8-13. French Enhanced Keyboard

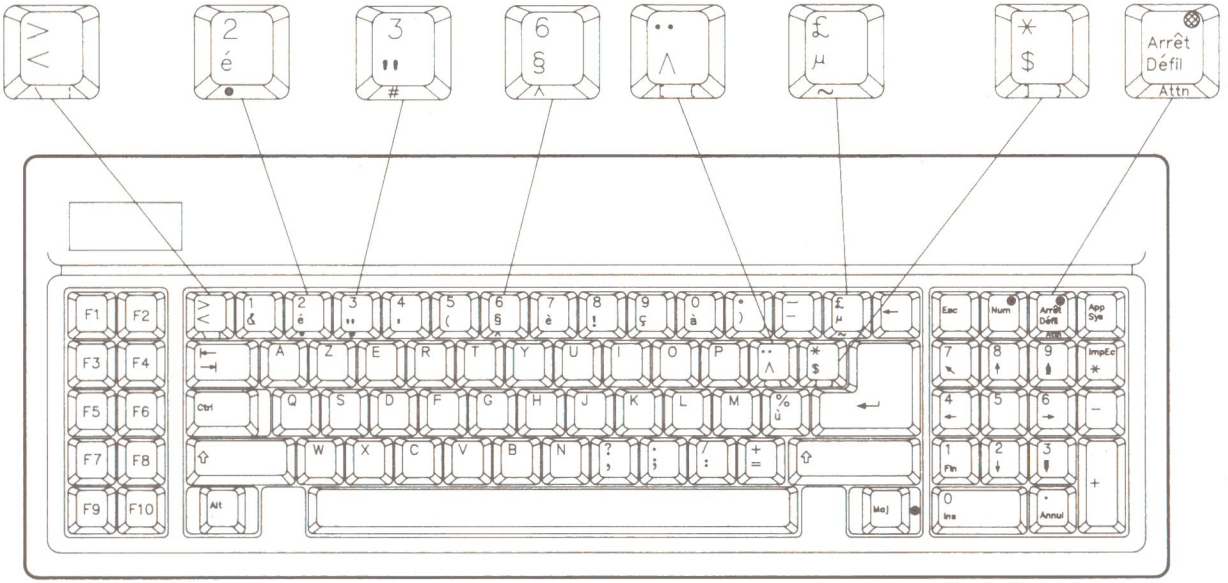


Figure 8-14. French 84-Key Keyboard

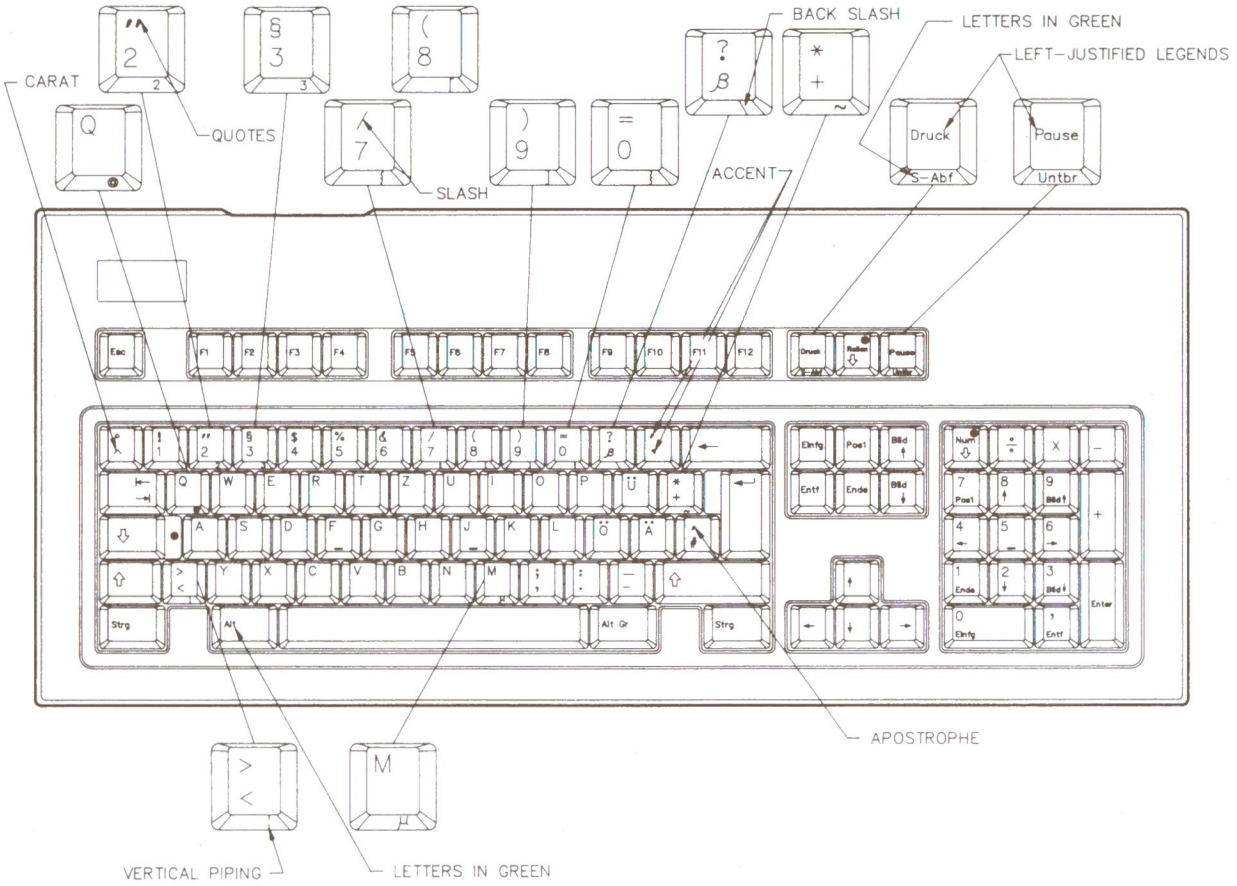


Figure 8-15. German Enhanced Keyboard

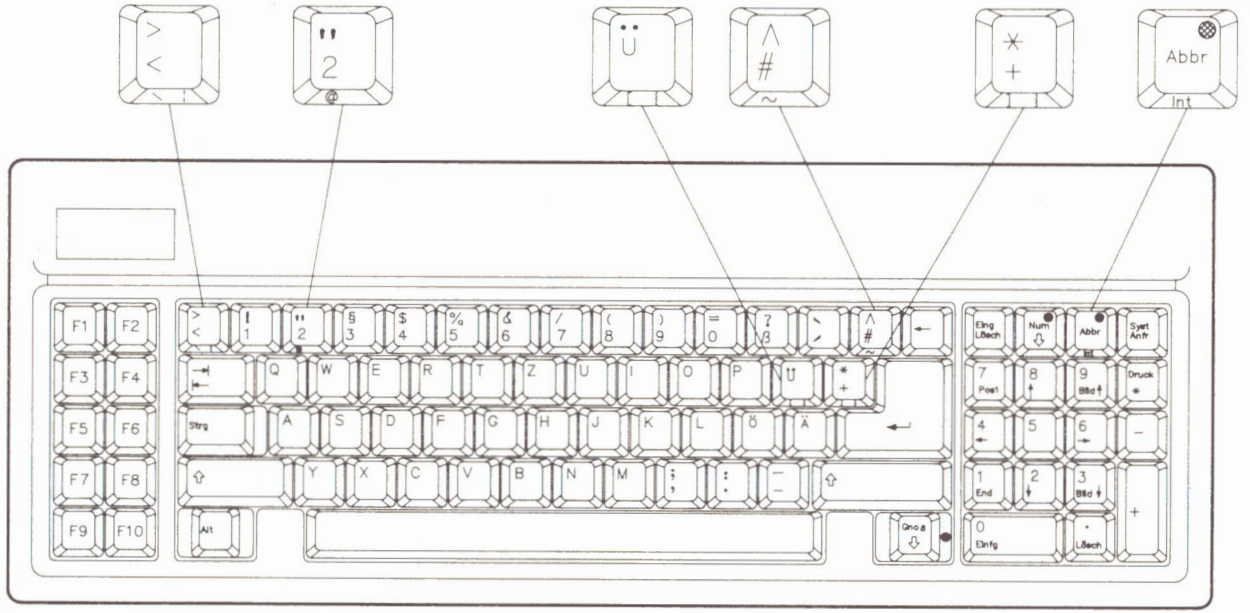


Figure 8-16. German 84-Key Keyboard

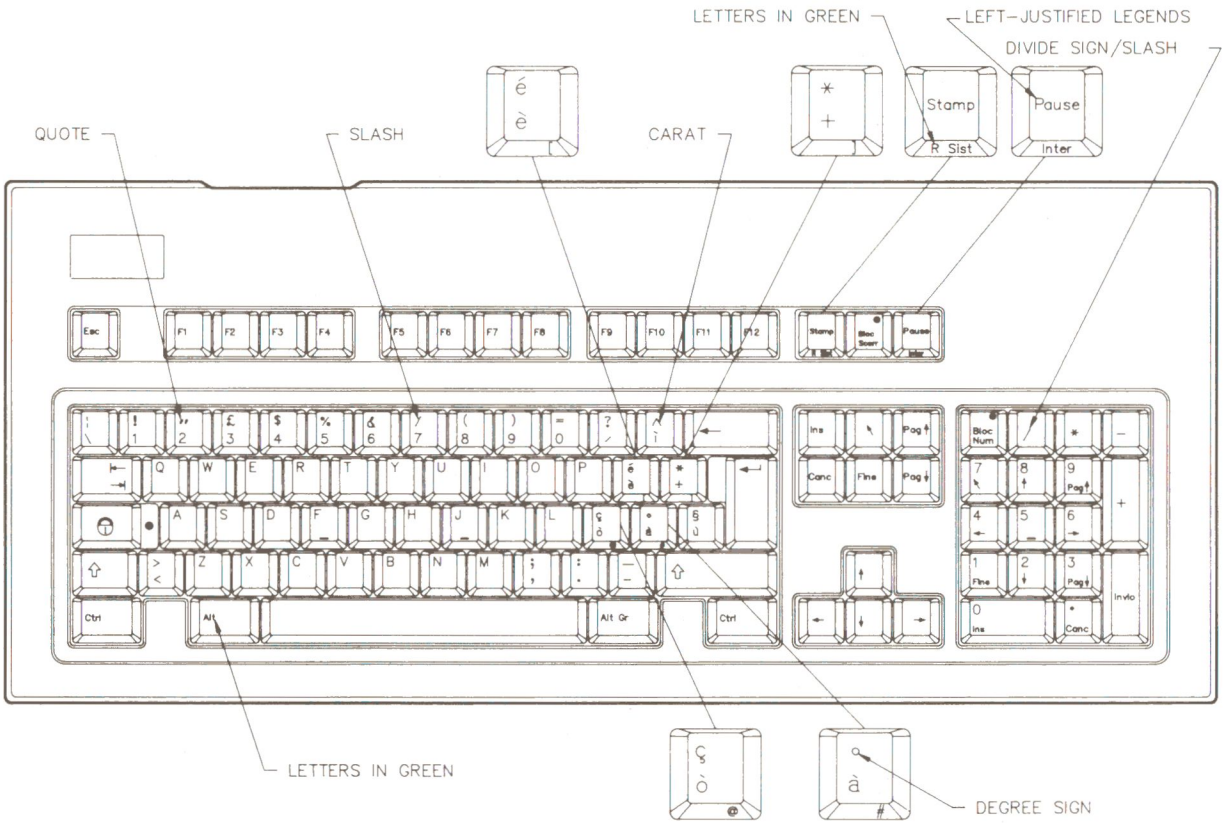


Figure 8-17. Italian Enhanced Keyboard

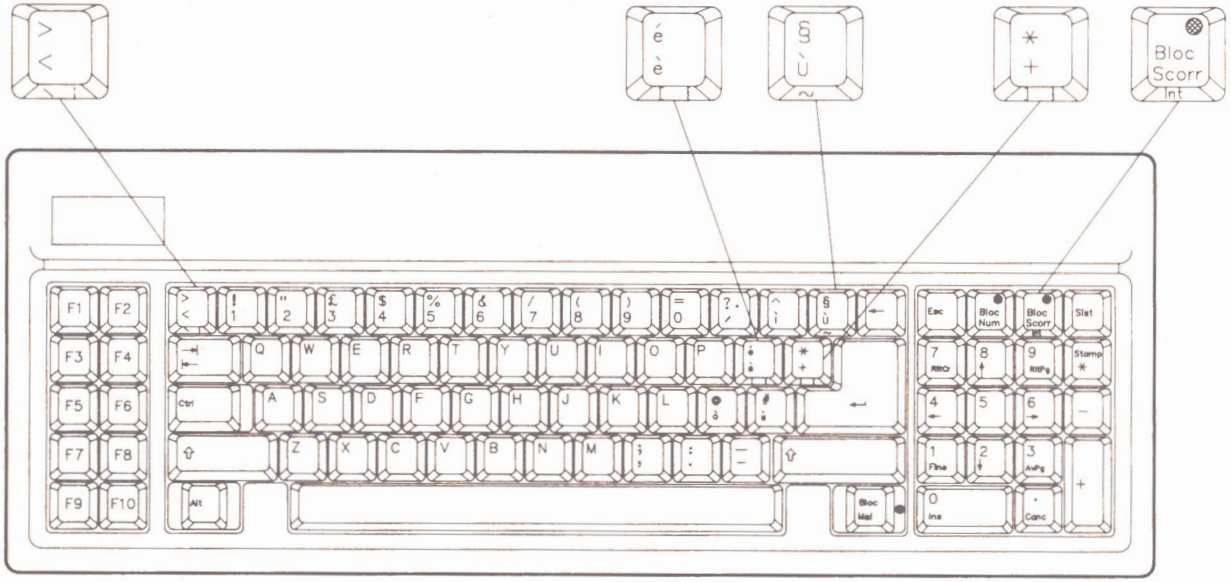


Figure 8-18. Italian 84-Key Keyboard

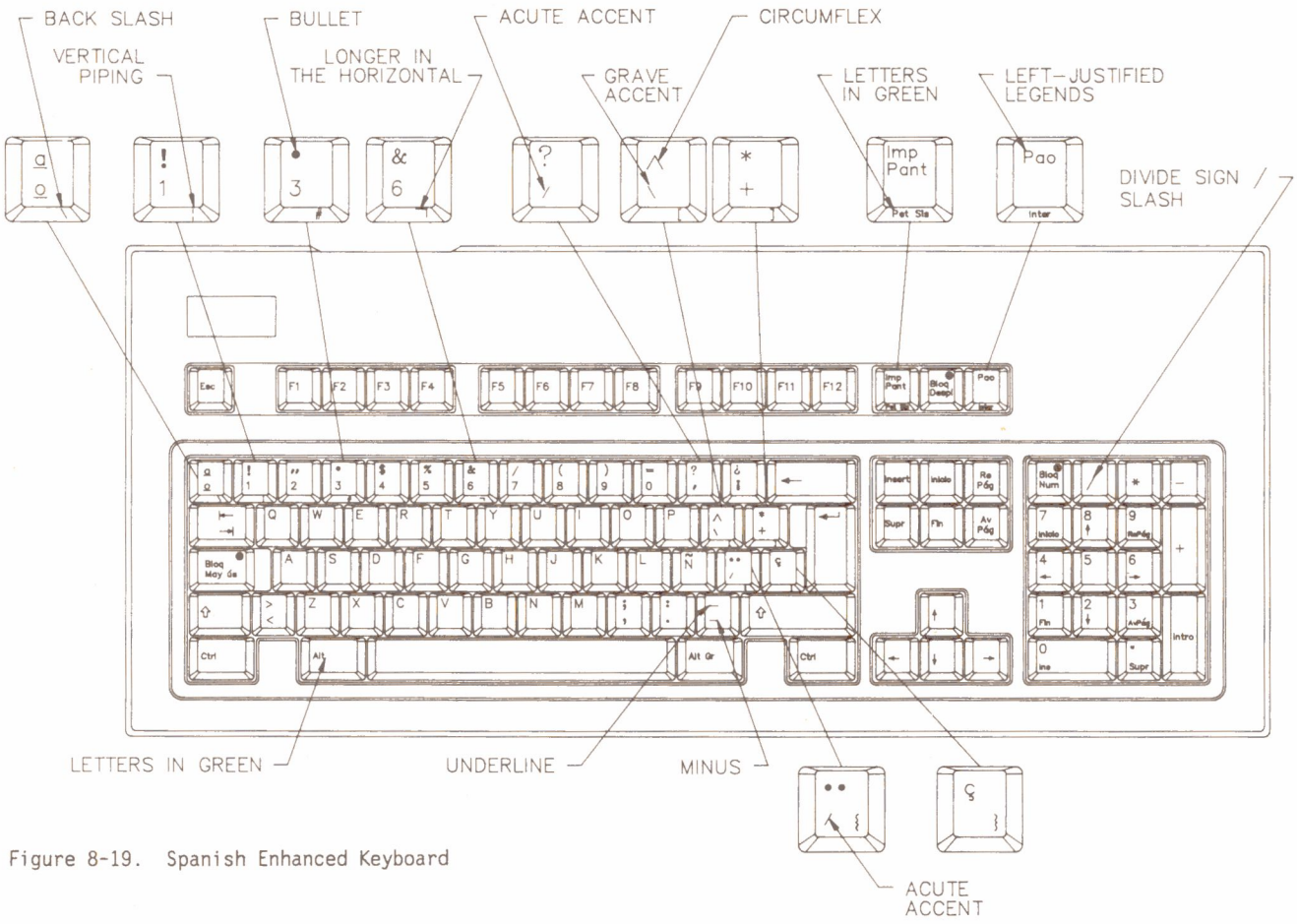


Figure 8-19. Spanish Enhanced Keyboard

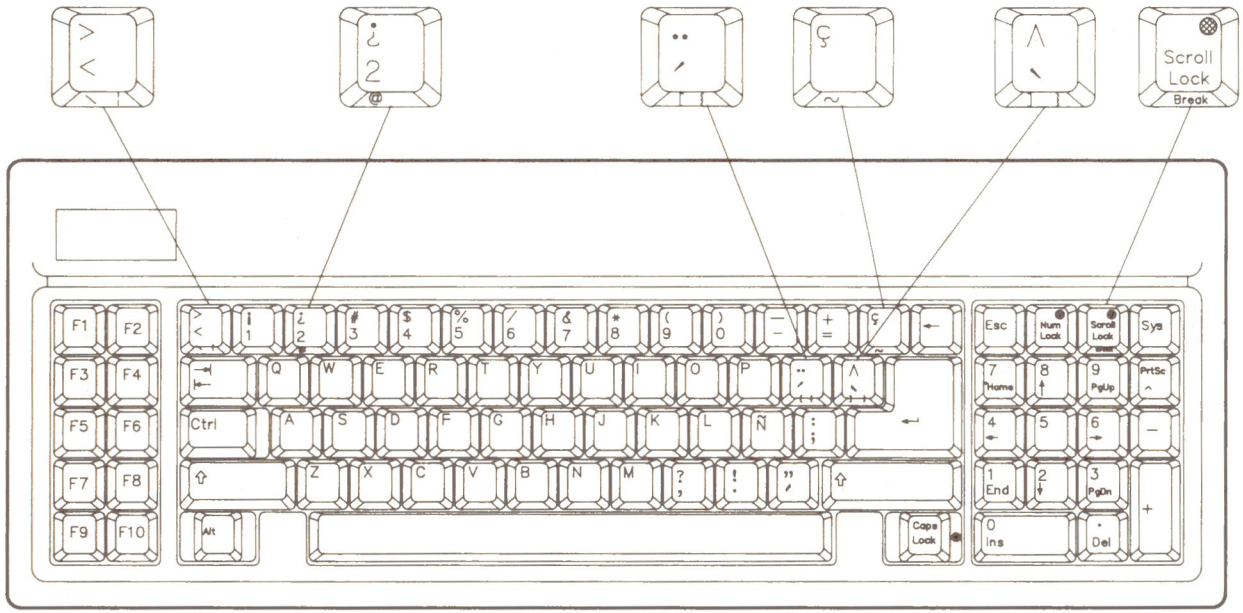


Figure 8-20. Spanish 84-Key Keyboard

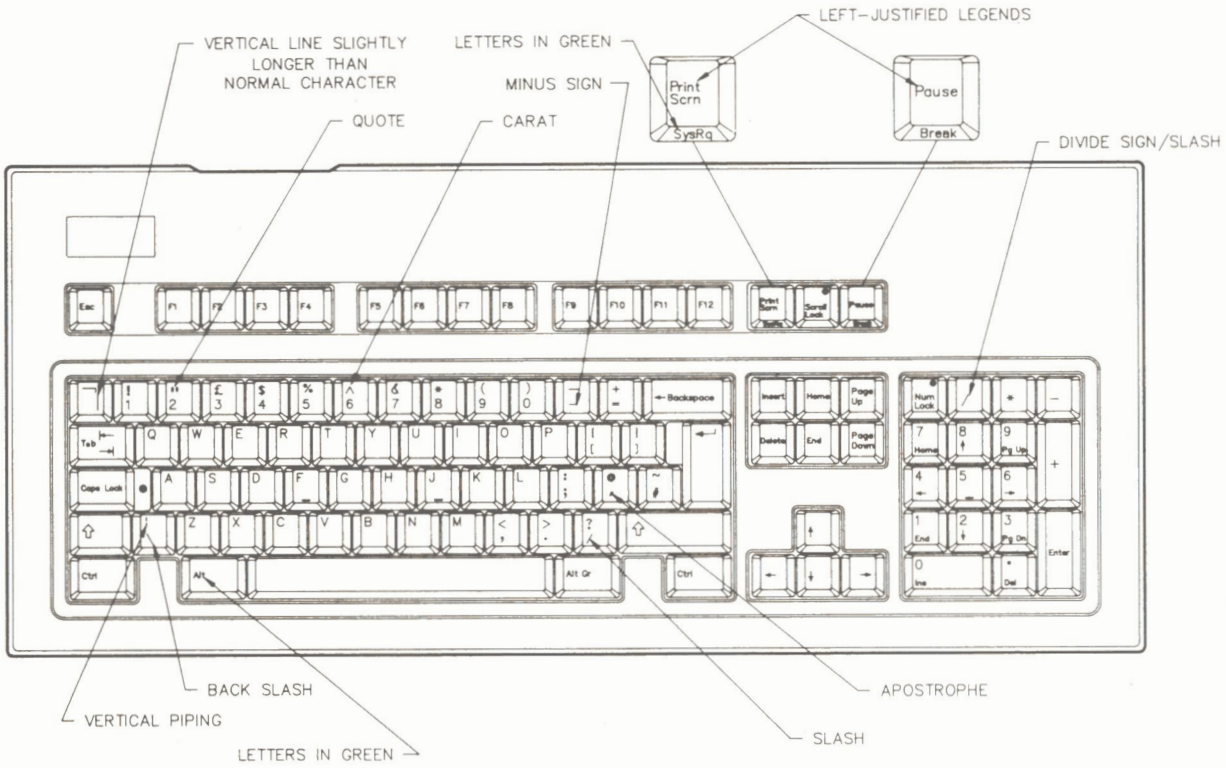


Figure 8-21. United Kingdom Enhanced Keyboard

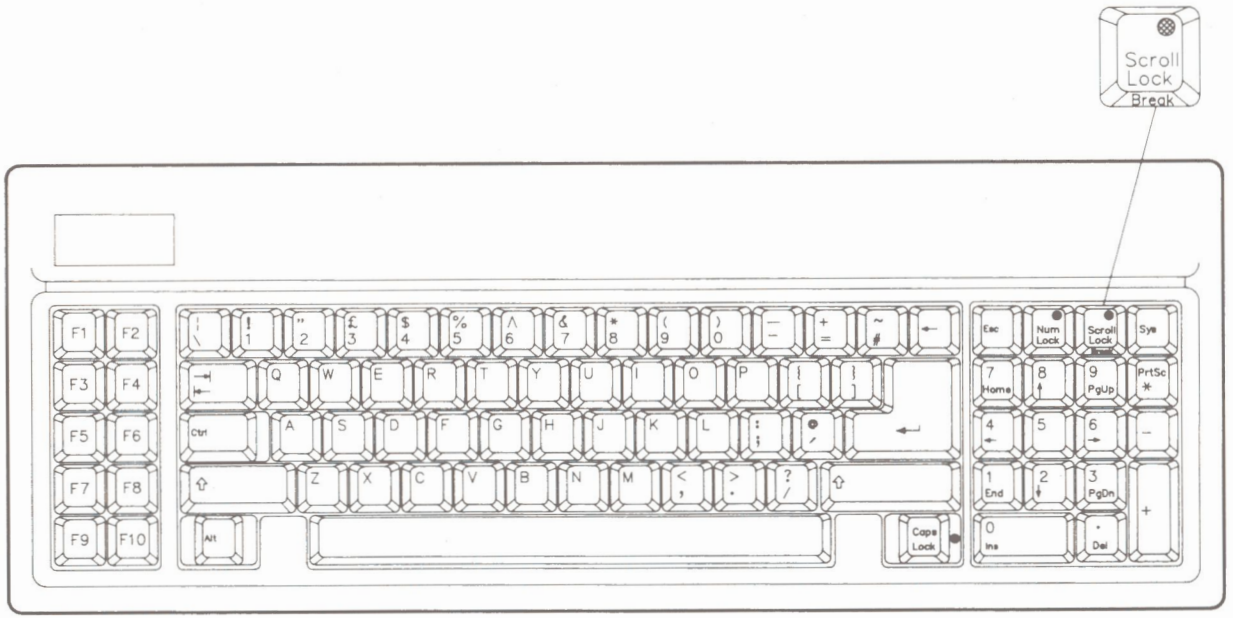


Figure 8-22. United Kingdom 84-Key Keyboard

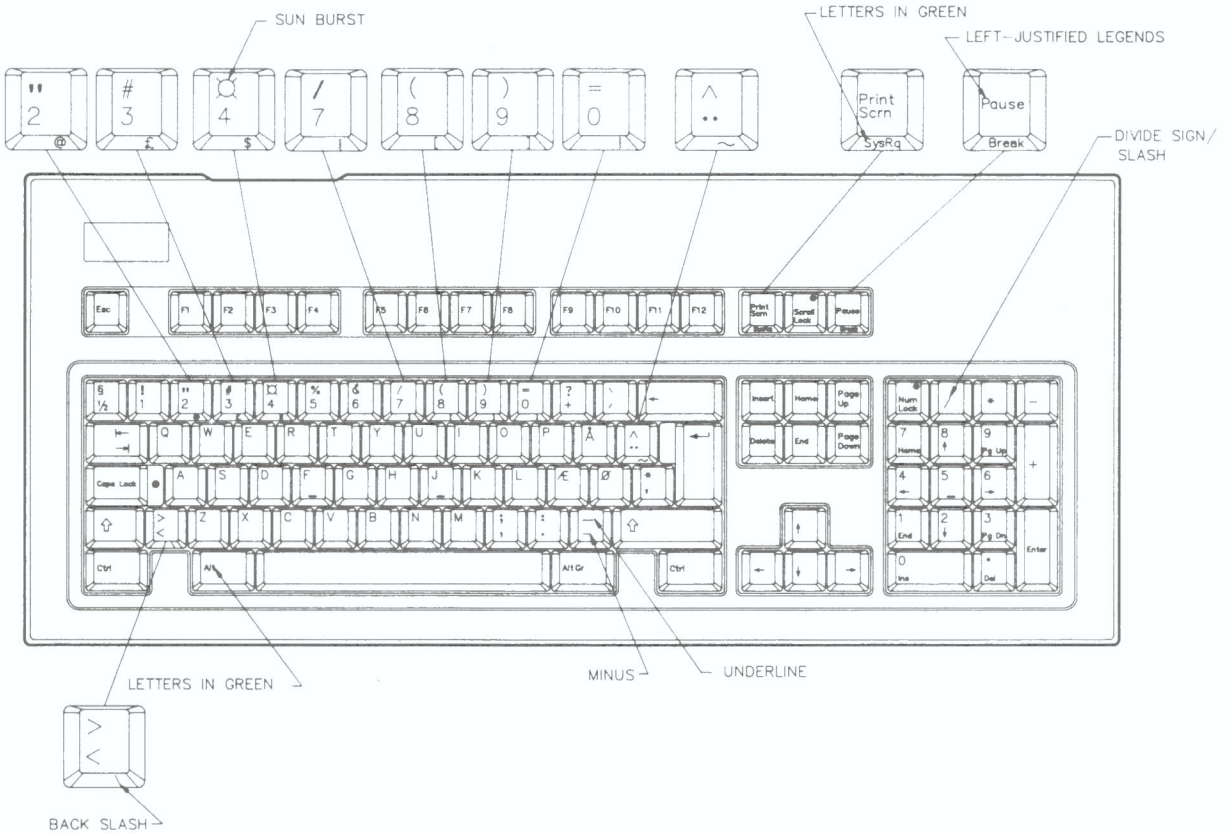


Figure 8-23. Danish Enhanced Keyboard

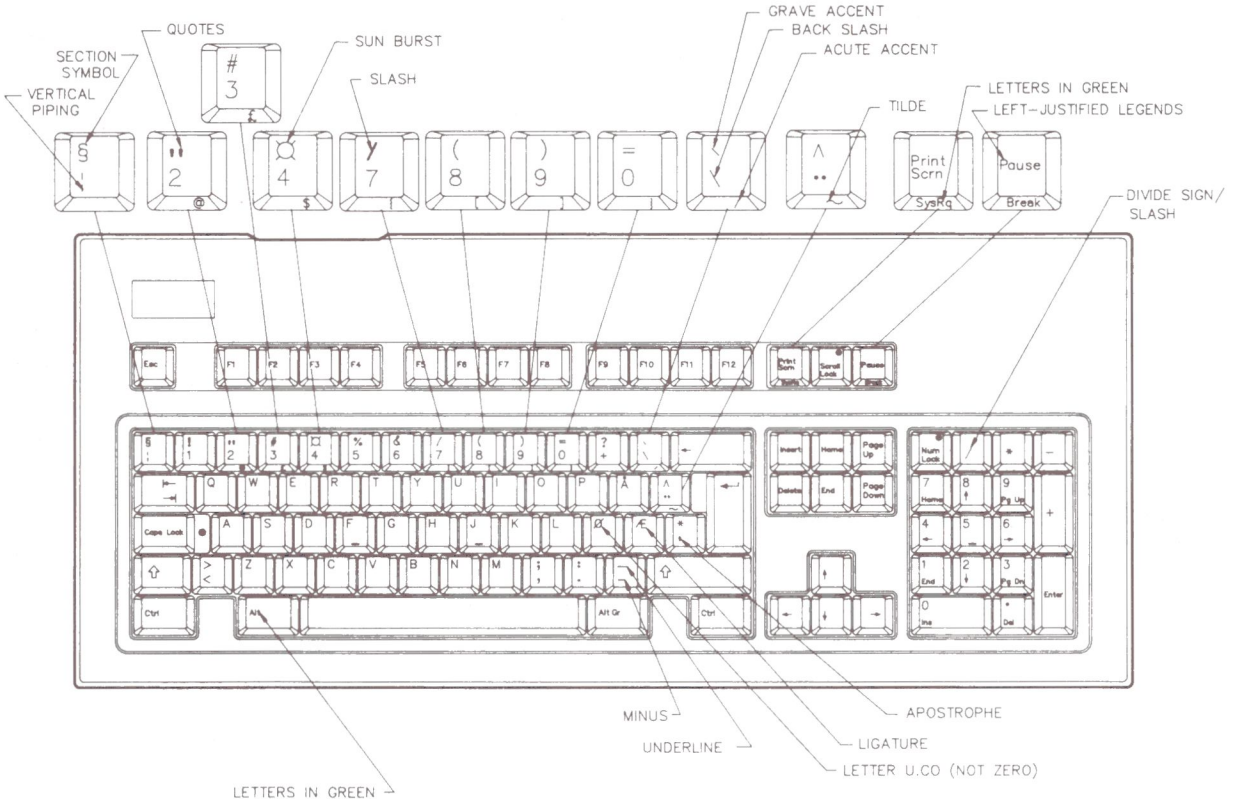


Figure 8-24. Norwegian Enhanced Keyboard

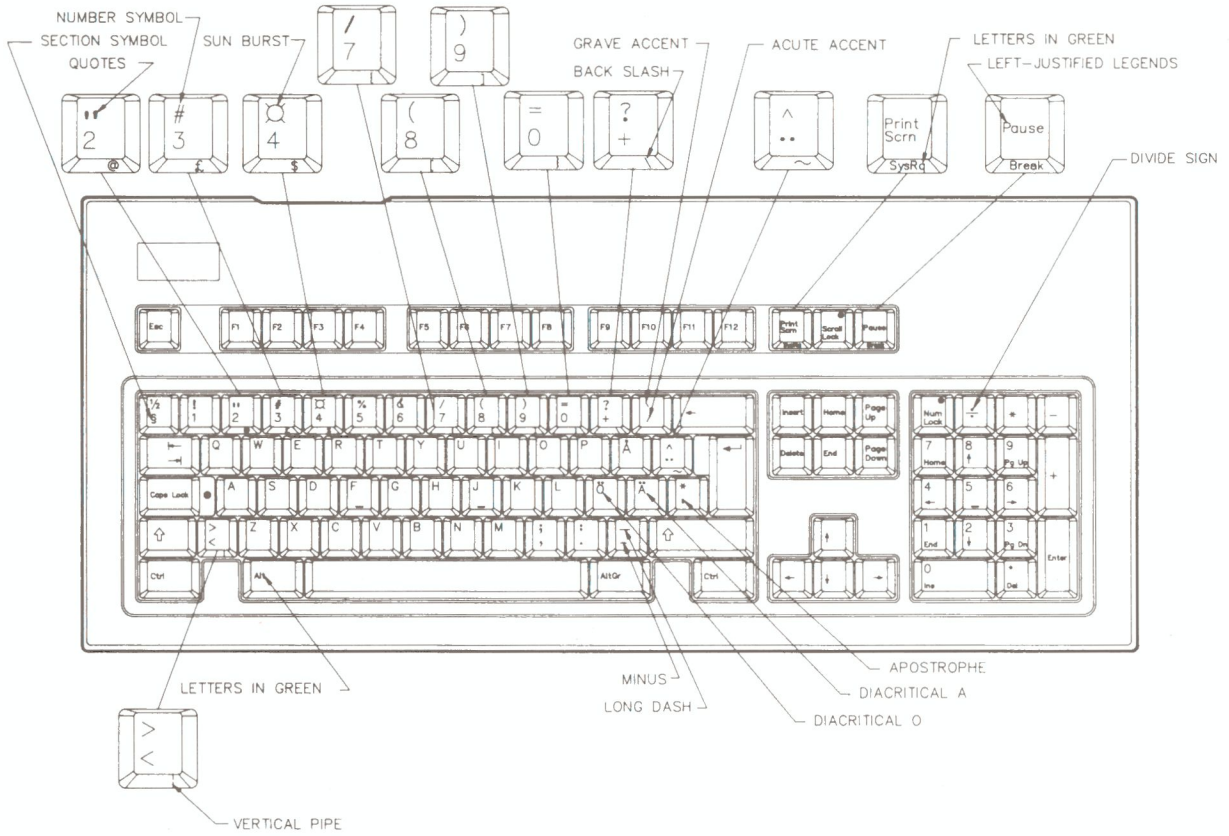


Figure 8-25. Swedish/Finnish Enhanced Keyboard

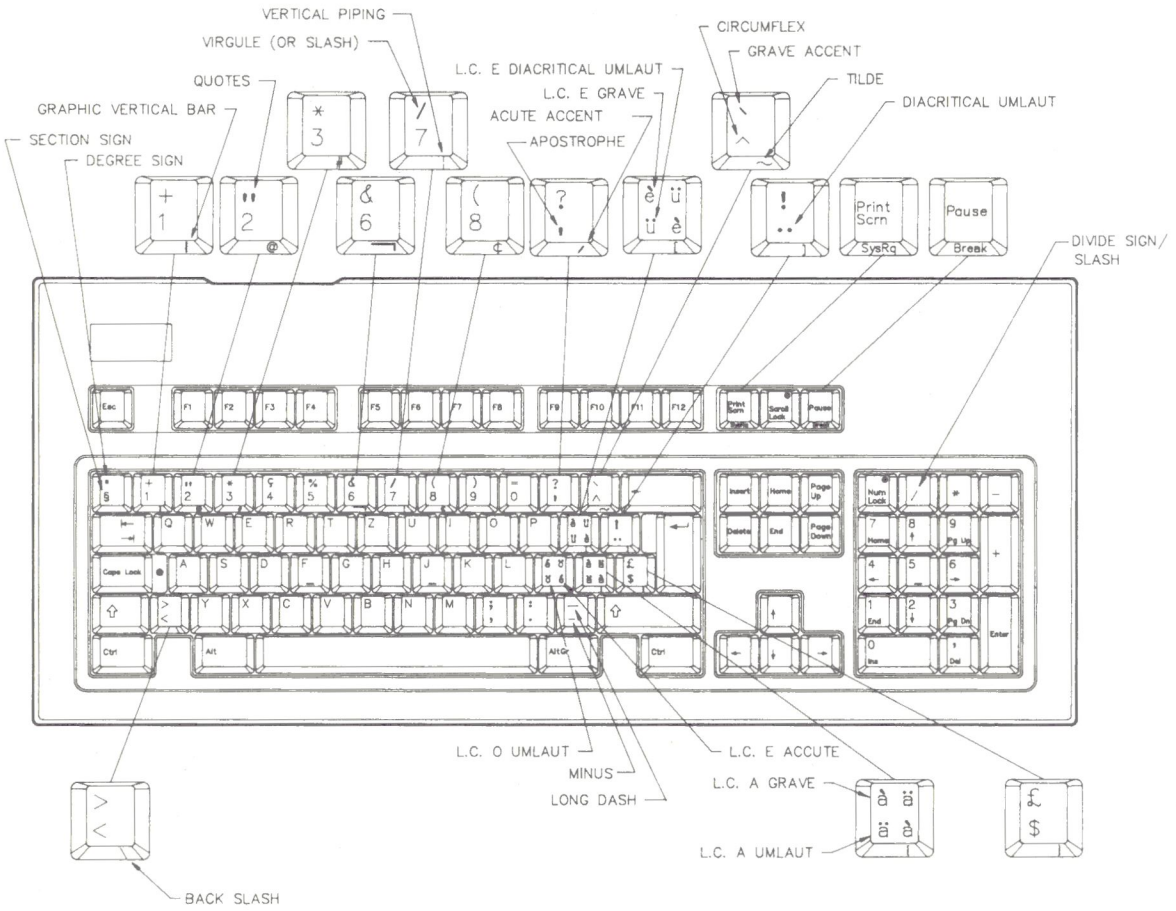


Figure 8-26. Swiss Enhanced Keyboard

Chapter 9
POWER SUPPLY

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CHAPTER 9
POWER SUPPLY

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Chapter 9
POWER SUPPLY

9.1 INTRODUCTION

The COMPAQ PORTABLE 286® and COMPAQ DESKPRO 286® Personal Computers use a switching-type power supply to provide high-amperage, low-noise, DC power for the system.

Figure 9-1 shows the power supply for the COMPAQ PORTABLE 286. Figure 9-2 shows the power supply for the COMPAQ DESKPRO 286.

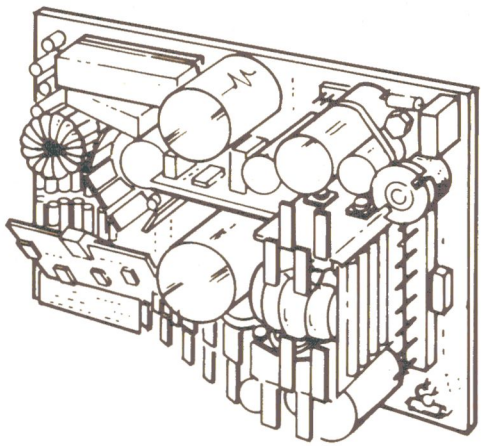


Figure 9-1. COMPAQ PORTABLE 286 Power Supply

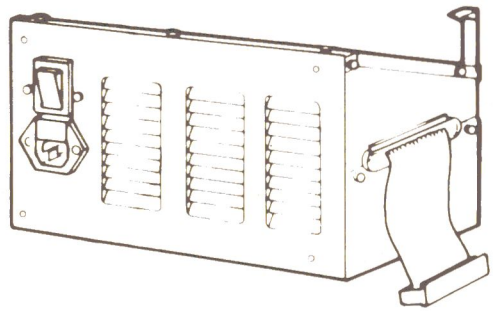
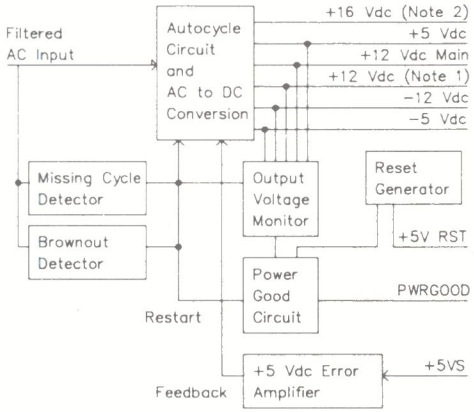


Figure 9-2. COMPAQ DESKPRO 286 Power Supply

9.2 FUNCTIONAL DESCRIPTION

The power supply provides four voltage levels for the system (+5 Vdc, -5 Vdc, +12 Vdc, and -12 Vdc). The +12 Vdc is provided as two separate outputs, main and auxiliary, to provide better power regulation. The COMPAQ PORTABLE 286 also provides +16 Vdc (unregulated) for the cooling fan.

Figure 9-3 shows the functional block diagram for both systems.



Notes: 1. This signal is +12 Vdc MON for the COMPAQ PORTABLE 286. It is 12 Vdc AUX for the COMPAQ DESKPRO 286.
2. COMPAQ PORTABLE 286 only.

Figure 9-3. Power Supply Functional Block Diagram

AC Input

The COMPAQ PORTABLE 286 and COMPAQ DESKPRO 286 have power supplies with jumper-selectable inputs to select 120 volt (North American) or 220-240 volt (international) AC power input. The COMPAQ DESKPRO 286 has different cooling fans and AC power fuses for the North American and international versions. The COMPAQ PORTABLE 286 only requires a different AC power fuse.

NOTE: Only Authorized COMPAQ Computer Service Representatives should change the AC input configuration. Changing the AC input configuration invalidates the COMPAQ warranty. The label near the AC power switch states the AC input power requirements for your system.

Power-On Sequence

The power-on sequence guarantees that all outputs are above the specified low voltage limits within 100 ms of power-on. The output load determines the order and the amount of time after the PWRGOOD signal is active (high) in which the outputs reach their regulated voltage level. Signal +5VRST is also set high at or prior to PWRGOOD becoming active (high).

Power-Down Sequence

The power-down sequence is dependent on the same variables as the power-on sequence. The output load determines both the order in which the output voltages drop out of regulation and the time remaining after the PWRGOOD signal becomes inactive (low). The PWRGOOD signal goes low within 8 ms after the power switch is turned off.

Autocycle Circuitry

The Autocycle Circuitry is the heart of the fault-detection functions for the power supplies. When a fault is detected, the power supply shuts down for approximately two seconds, then tries to restart. If the fault still exists, the power supply stays off for another two seconds, then tries to restart again.

The following paragraphs describe the additional protection of fault-detection circuits that trigger the autocycle circuitry.

The overvoltage protection circuit provides two types of protection. First, all outputs have a zener diode that will short to ground any supply voltage that exceeds specifications. Second, the +5 Vdc output has an overvoltage crowbar circuit that triggers the autocycle function when the output exceeds 6.2 Vdc for the COMPAQ PORTABLE 286 or 5.6 Vdc for the COMPAQ DESKPRO 286.

The low voltage protection circuit monitors the DC outputs. When one of the outputs drops below the specified limit, it triggers the autocycle circuit.

The AC input overcurrent protection circuit is a fuse on the outside of the unit. The fuse rating varies with the model (see Table 9-1).

NOTE: The power supply for the 12-MHz COMPAQ DESKPRO 286 does not contain a missing power detector circuit.

The missing cycle detector monitors the AC power input. If the AC power input is interrupted for more than one-half cycle, it pulls the PWRGOOD signal low, thereby triggering the autocycle circuit.

The brownout protection circuit and the autocycle circuit are triggered if the AC input voltage drops to 65-100 Vac (North American) or 130-200 Vac (international) under nominal to heavy loads.

CAUTION

Do not attempt to disassemble or repair the power supply. There are no user-serviceable components. Never operate the power supply without a load.

9.3 SPECIFICATIONS

Tables 9-1 through 9-3 provide the power supply specifications.

Table 9-1. Power Supply Specifications

	COMPAQ PORTABLE 286	COMPAQ DESKPRO 286 (6 and 8 MHz)	COMPAQ DESKPRO 286 (12MHz Only)
Input AC voltage RMS:			
Domestic	102 to 132 VAC	102 to 132 VAC	102 to 132 VAC
International	204 to 264 VAC	204 to 264 VAC	204 to 264 VAC
Line frequency:	47 to 62 Hz	47 to 62 Hz	47 to 62 Hz
Input fuse rating:			
120 VAC RMS	3 A	4 A	5 A
220-240 VAC RMS	2.5 A	2.5 A	4 A
In-rush current (peak, over one line cycle interval):			
120 VAC	40 A	40 A	40 A
220-240 VAC	80 A	80 A	80 A
Environment:			
Temperature	41°F to 113°F (5°C to 45°C)	41°F to 113°F (5°C to 45°C)	41°F to 113°F (5°C to 45°C)
Altitude	0 to 10,000 ft (0 to 3 000 m)	0 to 10,000 ft (0 to 3 000 m)	0 to 10,000 ft (0 to 3 000 m)
Relative humidity	5% to 95%	5% to 95%	5% to 95%
Power dissipation (Note 1):			
Starting (Note 2)	200 W	200 W	220 W
Steady state	160 W	160 W	192 W

Notes: 1. These limits were established under the following conditions: 120 V, 60 Hz, 25°C, sea level, and 50% relative humidity.
2. Peak output power may be used on a 5-percent duty cycle, not to exceed 30-seconds continuous operation.

(Continued)

Table 9-1. (Continued)

	COMPAQ PORTABLE 286					COMPAQ DESKPRO 286				
	Current (A)					Current (A)				
Voltage:	Nominal	Min.	Max.	Abs. Max. (Note 3)	Regulation	Nominal	Min.	Max.	Abs. Max. (Note 3)	Regulation
+5 VDC	+5.0	1.5	15.0		(± 2%)	+5.0	1.5	15.0	(Note 4)	(± 2%)
+12 VDC	+12.25	1.0	5.0	7.0	(± 2%)	+12.25	1.0	5.0	7.0	(± 2%)
+12 VDC(Aux)	N/A					+12.25	0.0	5.0	7.0	(± 2%)
+12 VDC(MON)	+12.25	0.0	1.5	3.0	(± 2%)	N/A				
-5 VDC	-5.0	0.0	0.5		(± 5%)	-5.0	0.0	0.5		(± 5%)
-12 VDC	-12.0	0.0	1.0		(± 5%)	-12.0	0.0	0.5		(± 5%)
Over-Voltage Limits:										
+5 VDC	6.2 VDC					5.6 VDC				
+12 VDC	13.0 VDC					13.0 VDC				
-5 VDC	-5.6 VDC					-5.6 VDC				
-12 VDC	-13.0 VDC					-13.0 VDC				
Maximum Ripple/Output	50 mV RMS					50 mV RMS				

Notes: 3. Abs. Max = Absolute maximum current. The peak output power may be used on a 5-percent duty cycle, not to exceed 30-seconds continuous operation.

4. The maximum +5-VDC current is 20 amperes for the 12-MHz COMPAQ DESKPRO 286 Personal Computer.

Table 9-2. COMPAQ PORTABLE 286 Expansion Bus Slot Power Allocation

	Per Slot				Total (All Slots)			
	+5 Vdc	+12 Vdc	-12 Vdc	-5 Vdc	+5 Vdc	+12 Vdc	-12 Vdc	-5 Vdc
Configuration 1	3 A	1 A	0.3 A	0.2 A	7 A	2 A	0.3 A	0.2 A
Configuration 2	3 A	1 A	0.3 A	0.2 A	6 A	1 A	0.3 A	0.2 A
Configuration 3	3 A	1 A	0.3 A	0.2 A	6 A	1 A	0.3 A	0.2 A

Notes: 1. The amperage values given are the absolute maximum values.
2. Configuration 1 = unit with 1.2-megabyte diskette drive and 256 Kbytes RAM
Configuration 2 = unit with 1.2-megabyte diskette drive, 640 Kbytes RAM, and 20-megabyte fixed disk drive
Configuration 3 = unit with 1.2-megabyte diskette drive, 640 Kbytes RAM, 20-megabyte fixed disk drive, and fixed disk drive backup.

Table 9-3. 8-MHz COMPAQ DESKPRO 286 Expansion Bus Slot Power Allocation

	Per Slot				Total (All Slots)			
	+5 Vdc	+12 Vdc	-12 Vdc	-5 Vdc	+5 Vdc	+12 Vdc(main)	-12 Vdc	-5 Vdc
Configuration 1	3 A	1 A	0.3 A	0.2 A	8 A	2 A	0.3 A	0.2 A
Configuration 2	3 A	1 A	0.3 A	0.2 A	7 A	2 A	0.3 A	0.2 A
Configuration 3	3 A	1 A	0.3 A	0.2 A	7 A	1 A	0.3 A	0.2 A

Notes: 1. The amperage values given are the absolute maximum values.
2. Configuration 1 = unit with 1.2-megabyte diskette drive and 256 Kbytes RAM
Configuration 2 = unit with 1.2-megabyte diskette drive, 640 Kbytes RAM, and 20-megabyte fixed disk drive
Configuration 3 = unit with 1.2-megabyte diskette drive, 640 Kbytes RAM, 40-megabyte fixed disk drive, and fixed disk drive backup.
3. All Configurations are assumed to be using the COMPAQ keyboard and COMPAQ Dual-Mode Monitor.
4. +12 Vdc (Aux) is available only on system board connectors J109 and J110, supplies a maximum of 4 A, and is reserved for fixed disk drives or a fixed disk drive backup only.

Table 9-4. 12-MHz COMPAQ DESKPRO 286 Expansion Bus Slot Power Allocation

	Per Slot				Total (All Slots)			
	+5 Vdc	+12 Vdc	-12 Vdc	-5 Vdc	+5 Vdc	+12 Vdc(main)	-12 Vdc	-5 Vdc
Configuration 1	3 A	1 A	0.3 A	0.2 A	8 A	2 A	0.3 A	0.2 A
Configuration 2	3 A	1 A	0.3 A	0.2 A	7 A	2 A	0.3 A	0.2 A
Configuration 3	3 A	1 A	0.3 A	0.2 A	7 A	1 A	0.3 A	0.2 A

Notes: 1. The amperage values given are the absolute maximum values.

2. Configuration 1 = unit with 1.2-megabyte diskette drive and 256 Kbytes RAM
   Configuration 2 = unit with 1.2-megabyte diskette drive, 640 Kbytes RAM, and 20-megabyte fixed disk drive
   Configuration 3 = unit with 1.2-megabyte diskette drive, 640 Kbytes RAM, 40-megabyte fixed disk drive, and fixed disk drive backup.
3. All Configurations are assumed to be using the COMPAQ keyboard and COMPAQ Dual-Mode Monitor.
4. +12 Vdc (Aux) is available only on system board connectors J109 and J110, supplies a maximum of 4 A, and is reserved for fixed disk drives or a fixed disk drive backup only.

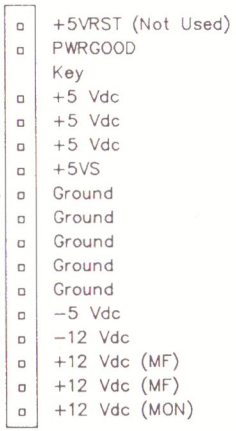
9.4 CONNECTORS

Table 9-5 describes the power supply signals. Figures 9-4 and 9-5 show the voltages or signals provided by the power supply to the system board.

Table 9-5. Power Supply Connector to the System Boards

Signal	COMPAQ PORTABLE 286 Pin	COMPAQ DESKPRO 286 Pin	I/O	Description
+5VRST (Note 1)	1	1	O	The +5VRST signal is regulated from the +15 Vdc line. This signal ranges from +4.8 Vdc to +5.2 Vdc
PWRGOOD	2	2	O	The PWRGOOD signal is controlled by the low voltage monitor and the missing cycle detector circuits. When all outputs are above the minimum values (see specifications), and there is no fault, the PWRGOOD signal is TTL high (+3.5 to +5.25 Vdc). If a low voltage condition is detected, the PWRGOOD signal is pulled low (less than 0.4 Vdc)
+5 Vdc	4,5,6	11,12,13	O	+5.0 Vdc
+5VS	7	14	I	The +5VS signal provides feedback from the system board. The power supply shuts down if the +5VS signal is interrupted or disconnected
Ground	8,9,10,11,12	6,7,8,9,19,20		Signal Ground
-5 Vdc	13	10	O	-5 Vdc
-12 Vdc	14	5	O	-12 Vdc
+12MF	15,16	N/A	O	+12 Vdc for everything except monitor
+12MON	17	N/A	O	+12 Vdc for internal monitor
+12VMAIN	N/A	15,18	O	+12 Vdc for J111 and J112 (Diskette drives A and B), J113 (COMPAQ Dual-Mode Monitor power), and expansion bus slots
+12VAUX	N/A	16,17	O	+12 Vdc for J109 and J110 (Fixed Disk Drive C and Fixed Disk Drive Backup)
No Connection	-	3,4	-	-

Note: There is no connection to this pin on the COMPAQ DESKPRO 286 with the 12-MHz system board.



Note: The maximum current for a single conductor (pin) must not exceed 5.0 A per line for +5 Vdc or 4.0 A for other lines.

Figure 9-4. COMPAQ PORTABLE 286 Power Supply Cable Signals

Note: The maximum current for a single conductor (pin) must not exceed 5.0 A per line for +5 Vdc or 4.0 A for other lines.

Figure 9-5. COMPAQ DESKPRO 286 Power Supply Cable Signals

Chapter 10

DISKETTE DRIVES

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Chapter 10
DISKETTE DRIVES

10.1 INTRODUCTION

The COMPAQ PORTABLE 286® and the COMPAQ DESKPRO 286® Personal Computer use 5.25-inch diskette drives, capable of storing either 1.2 megabytes or 360 kilobytes (Kbytes) of data.

A diskette drive is a device that spins a diskette around a hub, and reads and writes data to or from the diskette to provide data storage and access for a computer system.

A diskette drive has a diskette drive logic board that controls the diskette drive motor speed, read and write circuits, and other electronic circuits. The diskette drive logic board is mounted on the diskette drive. It connects to the:

- Ceramic heads, which read and write data to the diskettes
- Index sensor
- Door-closed sensor
- Write-protect sensor
- Stepper motor, which steps the heads back and forth
- Track-zero sensor
- Diskette (multipurpose controller board or multipurpose fixed disk controller board [12-MHz COMPAQ DESKPRO 286 only])

Various diskette drive logic boards use different connectors and pin arrangements for the internal drive functions. The connections to the multipurpose controller board or multipurpose fixed disk controller board and the DC power source remain the same.

A diskette drive has a main chassis, on which the diskette drive motor, stepper motor, head-carriage assembly, spindle, and diskette drive logic board are mounted. The left and right diskette guides, the front bezel, and the front-door mechanism are also mounted on the chassis.

Figure 10-1 shows a typical diskette drive chassis.

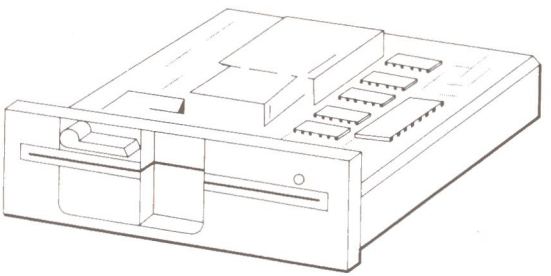


Figure 10-1. Typical Diskette Drive Chassis

Multiple diskette drives connect in a daisy-chain manner (one after another on the same cable) to the multipurpose or multipurpose fixed disk controller board.

Figure 10-2 shows a functional block diagram for a diskette drive.

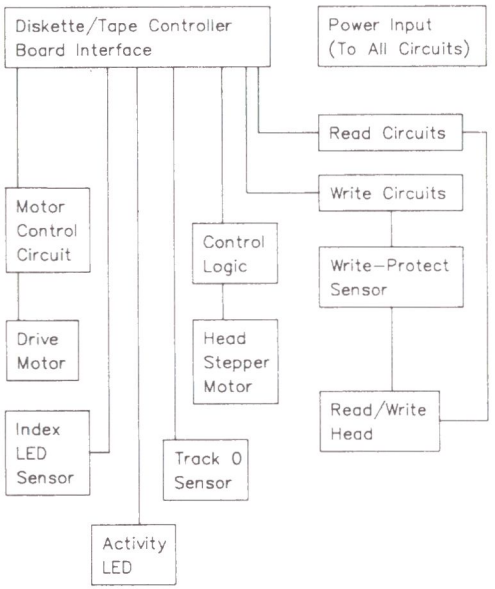


Figure 10-2. Diskette Drive Functional Block Diagram

10.2 FUNCTIONAL DESCRIPTION

This section provides a functional description for the 1.2-megabyte diskette drive and the 360-Kbyte diskette drive.

1.2-Megabyte Diskette Drive

The 1.2-megabyte diskette drive is a high-capacity diskette drive with the following features:

- Half-height, 5.25-inch diskette drive
- Two transfer rates--300 kb/s (double density) or 500 kb/s (high density)
- Stores data on 80 tracks (96 tracks per inch - TPI)

To read or write to 48-TPI media, the software must step the 96-TPI drive head twice between each 48-TPI track. Because the track width of the 96-TPI diskette drive is approximately half the track width of the 48-TPI diskette drive, standard 48-TPI diskette drives may not be able to read diskettes written by the 96-TPI drive in the 48-TPI format.

The multipurpose drive or multipurpose fixed disk controller cable determines diskette drive 1 (A) or 2 (B) selection. Both diskette drives are configured as the second physical diskette drive--Jumper DS1 (drive select 1) should be installed on both diskette drives. Jumpers DS0, DS2, and DS3 are not installed.

For systems with a 360-Kbyte diskette drive and a 1.2-megabyte diskette drive, the terminating resistors (register pack) should always be in the 1.2-megabyte diskette drive.

For systems with two 1.2-megabyte diskette drives, diskette drive 1 (A) should contain the resistor pack. No resistor pack should exist in diskette drive 2 (B).

360-Kbyte Diskette Drive

The 360-Kbyte Diskette Drive has the following features:

- Half-height 5.25-inch diskette drive
- Double sided, double density (DSDD) 40 tracks (48-TPI)

The multipurpose controller or multipurpose fixed disk controller cable determines diskette drive 1 (A) or 2 (B) selection. Both diskette drives are configured as the second physical diskette drive. Jumper DS2 (drive select 2) should be installed on both diskette drives. Jumpers DS1, DS3, and DS4 are not installed.

Some models of diskette drives refer to drive-select jumpers as DS0, DS1, DS2, and DS3, in which case, DS1 should be selected.

Diskette drive 1 (A) should always contain the resistor pack. No resistor pack should exist in diskette drive 2 (B).

10.3 SPECIFICATIONS

Table 10-1 lists the diskette drive physical and electrical specifications.

Table 10-1. Diskette Drive Physical and Electrical Specifications

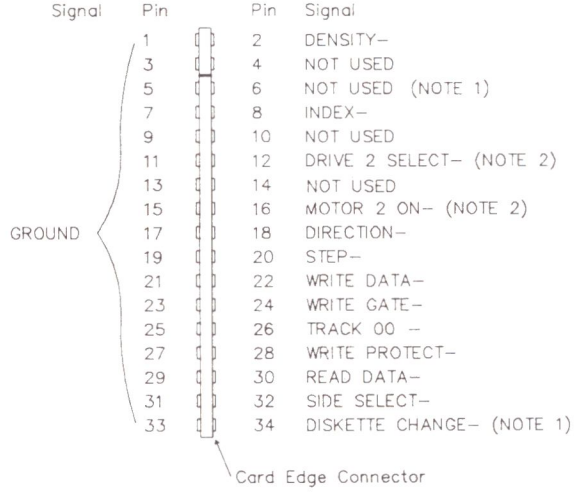
	1.2-Megabyte Diskette Drive	360-Kbyte Diskette Drive
Size:		
Width	5.8 in. (146 mm)	5.8 in. (146 mm)
Height	1.6 in. (41 mm)	1.6 in. (41 mm)
Depth	8.0 in. (203 mm)	8.0 in. (203 mm)
Capacity:		
Unformatted	1600 KB	500 KB
Formatted	1228.8 KB	368.64 KB
Flux reversal density:	9875 FRI (Track 79)	5876 FRI (Track 39)
Data transfer rate:	500 kb/s	250 kb/s
Sectors/track:	15	9
Bytes/sector:	512	512
Seek time:		
Track-to-track	3 ms	6 ms
Average	79 ms	80 ms
Settling time	15 ms	15 ms
Rotational speed	360 RPM ± 1.0%	300 RPM ± 1.5%
Motor start time	500 ms	500 ms

10.4 CONNECTORS

The electrical interface between the diskette drive and the multipurpose controller board or multipurpose fixed disk controller board consists of two connectors. The I/O signal connector J1 is a 34-pin board edge connector located at the rear of the drive, which handles all interface signals transmitted to and from the drive.

Figure 10-3 and 10-4 shows the diskette drive interface connectors. Reference pins 2 and 34 are numbered on the connector. Even-numbered pins are on the component side of the board, and odd-numbered pins are on the non-component side. A key slot is provided between pins 4 and 6 for optional connector keying.

DC power is provided to the diskette drive through connector J2 located near the rear of the board. Pin assignments are shown in Figure 10-4.



Notes: 1. Not applicable on 360 KB diskette drives.
2. DRIVE 2 SELECT– and MOTOR 2 ON– are the signals supplied by the diskette/tape controller for Diskette Drive 2 (B). If the diskette drive is Diskette Drive 1(A), the signals from the diskette/tape controller will be DRIVE 1 SELECT– and MOTOR 1 ON– (See Table 5–9).

Figure 10-3. Diskette Drive Control Connector

Table 10-2 lists the diskette drive control cable signals.

Table 10-2. Signals from the Diskette Drive Connector to Multipurpose or Multipurpose Fixed Disk Controller Board

Signal	Pin	I/O	Description
DENSITY-	2	I	For high-density (1.2-MB) drives, this signal selects High (500 kb/s) or Low (300 kb/s) mode (See Note)
DIRECTION-	18	I	Selects the direction to step the head when a step pulse is issued
DISKETTE CHANGE-	34	O	Indicates to multipurpose controller board that the drive door has been opened (and possibly different media installed) (See Note)
DRIVE SELECT-	10	I	Allows the selection of a diskette drive so that it can respond to the interface signals
INDEX-	8	O	Indicates to the multipurpose controller board that the media index hole is under the index sensor
MOTOR ON-	16	I	Activates the drive motor

(Continued)

Pin	Signal
1	+12 Vdc
2	Ground (+12 Vdc Return)
3	Ground (+5 Vdc Return)
4	+5 Vdc

Figure 10-4. Diskette Drive Power Connector

Table 10-2. (Continued)

Signal	Pin	I/O	Description
READ DATA-	30	O	This is the data stream read from the diskette containing clock and data signals
SIDE SELECT-	32	I	Selects Side 0 (Head 0) or Side 1 (Head 1)
STEP-	20	I	Tells the diskette drive to step the heads one track
TRACK 00-	26	O	Indicates to the diskette drive controller that the heads are at Track 0
WRITE DATA-	22	I	This stream of data is written to the diskette when WRITE GATE- is enabled
WRITE GATE-	24	I	Enables the diskette drive's write circuits so data from the WRITE DATA- signal is written
WRITE PROTECT-	28	O	Indicates to the multipurpose or multipurpose fixed disk controller board that the media is write protected

Note: The DENSITY- and DISKETTE CHANGE- signals are not used on 360-Kbyte (48-TPI) diskette drives.

Chapter 11

FIXED DISK DRIVES

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FIXED DISK DRIVES

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Chapter 11
FIXED DISK DRIVES

11.1 INTRODUCTION

COMPAQ 80286-based computer products use fixed disk drives that are compatible with either the ST506 standard interface or the COMPAQ 16-bit custom interface. These interfaces specify connector pinouts, signal definitions, and signal types for fixed disk drives.

Fixed disk drives available to these systems include 20 and 40 megabyte versions with the COMPAQ 16-Bit custom interface and 20, 30, and 70-megabyte versions with the ST506 standard interface.

A fixed disk drive is a device that spins a rigid disk surface, and reads or writes data to or from the disk to provide data storage and access for a computer system.

Fixed disk drives:

- Are sealed units. The media (disk surfaces) are not removable.
- Rotate the media at 3600 RPM
- Have a much higher data-transfer rate and faster access time than diskette drives.

All fixed disk drives have the same general components:

- A sealed head-disk assembly containing the disk platters, heads, and drive motor
- A drive-logic circuit board that controls the fixed disk drive's motors and the read and write electronics.

Some fixed disk drives have the controller electronics integrated with the drive electronics (COMPAQ 16-bit interface). These drives require only a host adapter to the system bus as opposed to the separate controller required by the ST506 interface.

Figure 11-1 shows the functional block diagram for a fixed disk drive.

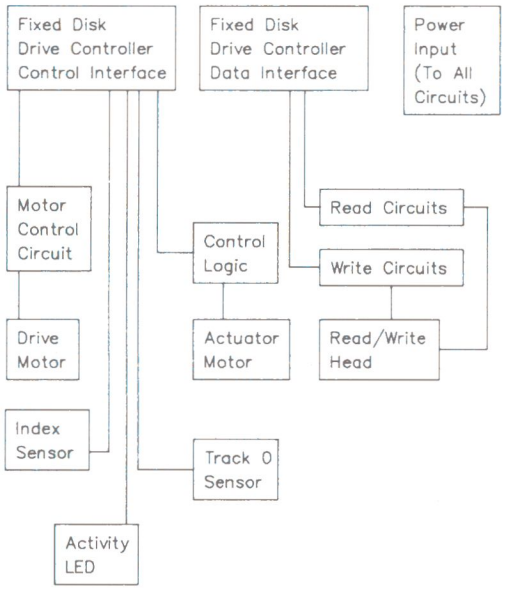


Figure 11-1. Fixed Disk Drive Functional Block Diagram

11.2 CONFIGURATION

A fixed disk drive controller is I/O mapped into specific I/O addresses. Generally, a jumper on the fixed disk drive controller specifies the base I/O address for that controller.

The fixed disk drive controller responds to commands given to it, and takes control of the system as needed to transfer information.

Two fixed disk drive controllers cannot occupy the same I/O address without causing bus contention and possibly damaging the system.

The COMPAQ 80286-based computer products may have nine different fixed disk drive configurations. The nine possible configurations are:

- One or Two 5.25" 40-megabyte, COMPAQ Interface
- One or Two 3.50" 40-megabyte, COMPAQ Interface
- One or Two 3.50" 20-megabyte, COMPAQ Interface
- One 5.25" 70-megabyte, ST506 Interface
- One 5.25" 30-megabyte, ST506 Interface
- One 5.25" 20-megabyte, ST506 Interface

ST506 fixed disk drives should have their drive select jumpers set to DS1. The COMPAQ Dual Fixed Disk Drive Control Cable automatically selects the second fixed disk drive. Refer to Chapter 5 in this guide for information on setting the correct jumper settings required for a particular fixed disk configuration.

ST506 fixed disk drives require that a terminating resistor pack be installed only on the last fixed disk drive on the control cable. Fixed disk drives with the COMPAQ 16-Bit interface do not require a terminating resistor pack at the drive.

COMPAQ 16-Bit fixed disk drives are configured for single or dual-mode according to the jumper settings in Table 11-1.

Table 11-1. Fixed Disk Drive Jumper Settings

Jumper		Function
Drive 1	Drive 2	
E7,E5	N/A	One 3.5-inch 20 or 40 megabyte drive
E7,E6	E6	Two 3.5-inch 20 or 40 megabyte drive
J3 IN:C installed	N/A	One 5.25" 40 megabyte drive
J3 IN:C installed	J1 IN:C removed	Two 5.25" 40 megabyte drive

11.3 SPECIFICATIONS

Table 11-2 lists the physical and electrical specifications for the fixed disk drive.

Table 11-2. Fixed Disk Drive Physical and Electrical Specifications

	PORTABLE 286 3.5in.,20MB	DESKPRO 286 5.25in.,20MB	DESKPRO 286 5.25in.,30MB	DESKPRO 286 5.25in.,70MB	DESKPRO 286 5.25in.,40MB	PORTABLE 286 3.5in.,40MB
Capacity (megabyte):						
Unformatted	26.69	25.62	36.32	86.78	51.08	53.66
Formatted	21.41	21.41	30.33	72.46	42.65	42.65
Drive type (Used in SETUP program)	2	2	6	12	17	17
Data transfer rate (mb/s)	8.0	5.0	5.0	5.0	5.0	8.0
Rotational speed (RPM)	3600	3600	3600	3600	3600	3600
Number of heads (logical)	4	4	5	9	5	5
Average Access Time (ms)	29	105	40	29	29	29
Number of cylinders (logical)	615	615	697	925	980	980
Write precompensation cylinder	128	128	128	128	128	128
Landing zone cylinder	638	638	696	924	980	980
Size:						
Width (in. (mm))	4.1 (104)	5.8 (146)	5.8 (146)	5.8(146)	5.8 (146)	4.1 (104)
Height (in. (mm))	1.7 (43)	1.7 (43)	3.4 (43)	3.4 (86)	1.7 (43)	1.7 (43)
Depth (in. (mm))	5.8 (146)	8.0 (203)	8.0 (203)	8.0 (203)	8.8 (223)	5.8 (146)
Weight (lb (kg))	1.8 (0.8)	3.5 (1.6)	7.5 (3.4)	8.0 (3.6)	4.2 (1.9)	1.8 (0.8)
Interface	COMPAQ 16	ST506	ST506	ST506	COMPAQ 16	COMPAQ 16

11.4 ST506 INTERFACE CONNECTORS

The fixed disk drive controller board with ST506 standard interface connects to the fixed disk drive via two cables: the control cable and the data cable. The control cable connects in a daisy-chain manner to all the fixed disk drives in the system. A separate data cable connects the fixed disk drive controller to each fixed disk drive.

Tables 11-3 and 11-4 list the fixed disk drive connector signals. Figures 11-2 through 11-4 show the connectors.

Table 11-3. Fixed Disk Drive Control Cable Signals

Signal	Pin	I/O	Description
DIRECTION IN-	34	I	Defines the direction of motion of the heads when the fixed disk drive is executing a seek.
DRIVE SELECT 1-	26	I	Indicates that Fixed Disk Drive 1 is to respond to the control signals on the fixed disk drive control bus.
DRIVE SELECT 2-	28	I	Indicates that Fixed Disk Drive 2 is to respond to the control signals on the fixed disk drive control bus.
GROUND	All Odd No. Pins		Signal ground
HEAD SELECT 2^0-	14	I	First and least-significant bit of the binary-coded head-select address.
HEAD SELECT 2^1-	18	I	Second bit of the binary-coded head-select address.
HEAD SELECT 2^2-	4	I	Third bit of the binary-coded head-select address.
INDEX-	20	O	Indicates the beginning of a track.

(Continued)

Table 11-3. (Continued)

Signal	Pin	I/O	Description
REDUCED WRITE CURRENT-/ HEAD SELECT 2^3-	2	I	Functions as the reduced write current signal or a head-select 2^3 bit. The control bit for this selection is in the fixed disk drive control register. In the reduced write current mode, this line, in conjunction with the WRITE GATE- signal, reduces the magnitude of the write current for writing on inner-disk cylinders. In the head-select mode, this pin is the fourth and most-significant bit of the head-select binary code.
READY-	22	O	When active together with SEEK COMPLETE-, this signal indicates that the fixed disk drive is ready to perform a read, write, or seek command.

(Continued)

Table 11-3. (Continued)

Signal Name	Pin	I/O	Signal Description
Reserved	16,30, 32	-- --	
SEEK COMPLETE-	8	O	Indicates that the heads have settled on the specified track at the end of a track seek operation.
STEP-	24	I	This signal causes the heads to move one track in the direction defined by the DIRECTION IN- signal.
TRACK 000-	10	O	Indicates that the heads are on track zero (000).
WRITE FAULT-	12	O	Indicates that a condition exists that may cause improper writing on the fixed disk and that writing is, therefore, inhibited.
WRITE GATE-	6	I	When active, allows data on the data cable +MFM WRITE DATA signal to be written on the fixed disk.

Note: All odd-numbered pins are Signal Ground.

Table 11-4. Fixed Disk Drive Data Cable Signals

Signal Name	Pin	I/O	Signal Description
DRIVE SELECTED-	1	O	When active, the fixed drive is selected and is responding to the control bus.
GROUND	2,4, 6,8, 11,12, 15,16, 19,20,	--	Signal Ground
+MFM WRITE DATA	13	I	MFM-encoded write data to be written to the fixed disk.
-MFM WRITE DATA	14	I	MFM-encoded write data to be written to the fixed disk.
+MFM READ DATA	17	O	MFM-encoded read data from the fixed disk.
-MFM READ DATA	18	O	MFM-encoded read data from the fixed disk.
Reserved	3,5,7	--	
Spare	9,10	--	

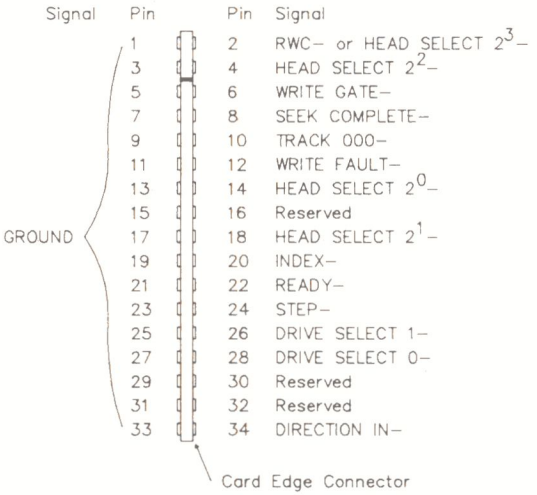


Figure 11-2. Fixed Disk Drive Control Cable Connector (ST506)

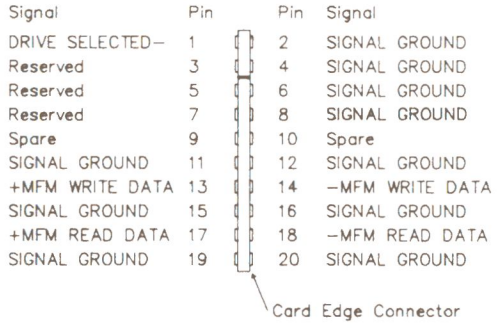


Figure 11-3. Fixed Disk Drive Data Cable Connector (ST506)

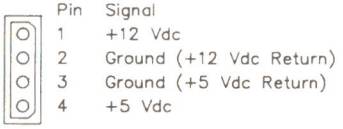


Figure 11-4. Fixed Disk Drive Power Cable Connector

11.5 COMPAQ 16-BIT INTERFACE CONNECTORS

The fixed disk drives with the COMPAQ 16-bit interface connector use a single 40-pin connector, which is defined in Table 11-5. The interface cable is capable of being connected in a daisy-chain configuration to control up to two fixed disk drives.

Table 11-5. COMPAQ 16-Bit Interface Connector

Pin Name	Pin Number	I/O	Signal Name	Signal Description
HRST-	1	I	Host reset	Reset signal from the host system that is active during power-on and inactive thereafter.
HD0	17	I/O	Host data bus	16-bit bidirectional data bus between the host and the fixed disk drives used for register and ECC byte access. All bits are used for data word transfers.
HD1	15			
HD2	13			
HD3	11			
HD4	9			
HD5	7			
HD6	5			
HD7	3			
HD8	4			
HD9	6			
HD10	8			
HD11	10			
HD12	12			
HD13	14			
HD14	16			
HD15	18			
HIOW-	23	I	Host I/O write	Write strobe, the rising edge of which clocks data from the host data bus, HD0 through HD15, into a register or the data port of the drive.

(Continued)

Table 11-5. (Continued)

Pin Name	Pin Number	I/O	Signal Name	Signal Description
HIOR-	25	I	Host I/O read	Read strobe, the falling edge of which enables data from a register or the data port of the drive onto the host data bus, HD0 through HD15. The rising edge of HIOR- latches data at the host.
HALE	28	I	Host address latch enable	Address valid indication from the host system. The host address and chip selects, HA0 through HA2, HCS0-, and HCS1-, are guaranteed valid on the falling edge of this signal. The address and chip select signals are held valid after the HALE falling edge by the host system; therefore, the drive need not latch these signals with HALE.
HIRQ	31	0	Host interrupt request	Interrupt to the host system, activated only when the drive CPU has a pending interrupt, the drive is selected, and the host activates the IEN- bit in the digital output register. When the IEN- bit is inactive, or the drive is not selected, this output is in a high-impedance state, regardless of the presence or absence of a pending interrupt.
HIO16	32	0	Host 16-bit I/O	Indication to the host system that the 16-bit data port has been addressed and that the drive is prepared to send or receive a 16-bit data word. This must be an open-collector output.
HA0	35	I	Host address bus	3-bit binary-coded address supplied by the host when accessing a register or the data base port in the drive.
PDIAG-	34	I/O	Passed diagnostic	Output by the drive if it is jumpered in the slave mode, and input to the drive if jumpered in the master mode. The signal indicates to a master that the slave has passed its internal diagnostic command. The master drive determines the state of this pin and returns the slave diagnostic status to the host with its own.

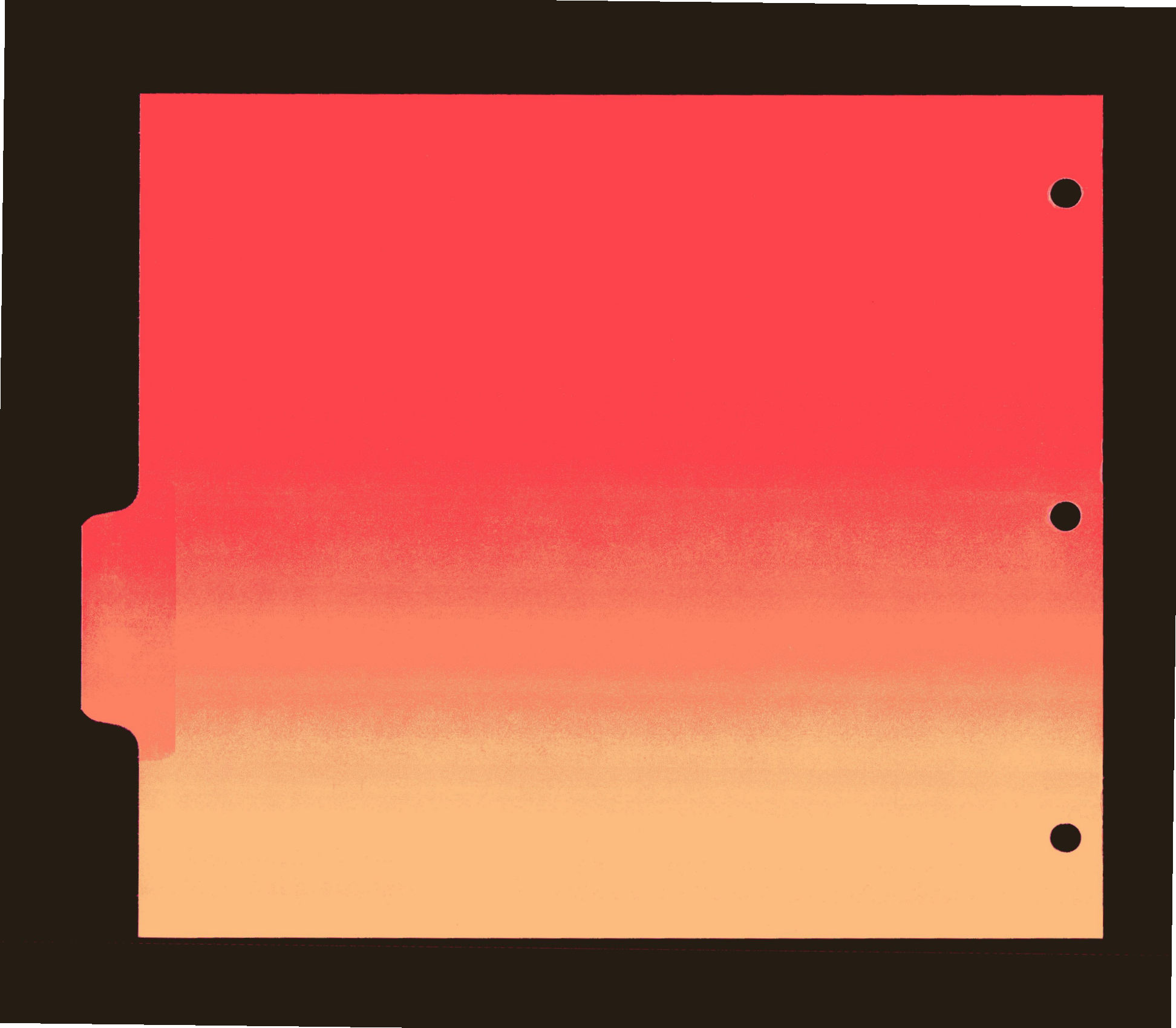
(Continued)

Table 11-5. (Continued)

Pin Name	Pin Number	I/O	Signal Name	Signal Description
HCS0-	37	I	Host chip select 0	Chip select decoded from the host address bus. Used to select some of the host accessible registers.
HCS1-	38	I	Host chip select 1	Chip select decoded from the host address bus. Used to select some of the host-accessible registers.
DASP-	39	I/O	Drive active/ slave present	Time-multiplexed signal that indicates drive active or slave present. When the drive is executing a diagnostic command, this line is an output from a slave drive, and and input to a master drive indicating that a slave drive is present. At all times other than during diagnostics, this line is an output from both master and slave drives which is active when the drive is selected and being accessed (BSY is active), and is used to drive an activity LED indicator. This signal must be an open-collector output.
GND	2 19 22 24 26 30 40	-	Ground	Signal ground returns for the interface lines.
RSVD	21 27 29	-		Reserved pins.
KEY	20	-		Pin used for keying the interface connector.

Chapter 12

FIXED DISK DRIVE BACKUPS



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Chapter 12
FIXED DISK DRIVE BACKUP SYSTEMS

12.1 INTRODUCTION

The 40-megabyte fixed disk drive backup uses a 3M® DC 2000 tape cartridge or equivalent and the COMPAQ® TAPE Utility Version 2.0 (or later) or other Tape Utilities to provide a data backup for fixed disk drives. The 40-megabyte fixed disk drive backup stores a maximum of 40 megabytes of data on a single tape cartridge. 3M DC 1000 tape cartridges, which were created on a 10-megabyte fixed disk drive backup, can be read on a 40-megabyte fixed disk drive backup, but cannot be written.

The 10-megabyte fixed disk drive backup uses a 3M DC 1000 tape cartridge or equivalent and the COMPAQ TAPE Utility Version 1 to provide a data backup for fixed disk drives. The fixed disk drive backup stores up to 10 megabytes of data on a single tape cartridge.

The fixed disk drive backup is connected in a daisy-chain manner with the diskette drives. An NEC765A diskette controller controls all fixed disk drive backup functions and data formats.

Figure 12-1 shows the fixed disk drive backup systems.

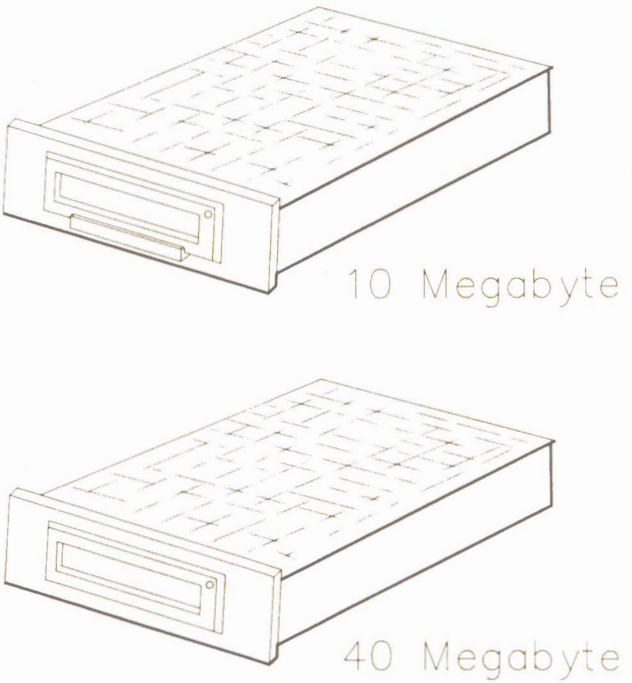

Figure 12-1. Fixed Disk Drive Backup Systems (Tape Drive)

The fixed disk drive backup consists of a microprocessor, firmware, stepper motor, drive motor, read/write head, and a control logic board.

The 40-megabyte and 10-megabyte fixed disk drive backup logic board uses a Z8 microprocessor with 8 kbytes of ROM to control the drive. The logic board connects to the:

- Movable head, which reads and writes data
- Cartridge-installed sensor
- Write-protect sensor
- End-of-tape/beginning-of-tape (EOT/BOT) sensor
- Stepper motor, which positions the head
- DC power supply
- Drive Motor, which advances and rewinds the tape
- Diskette/Tape Controller Board

Figure 12-2 is a functional block diagram of the fixed disk drive backup systems.

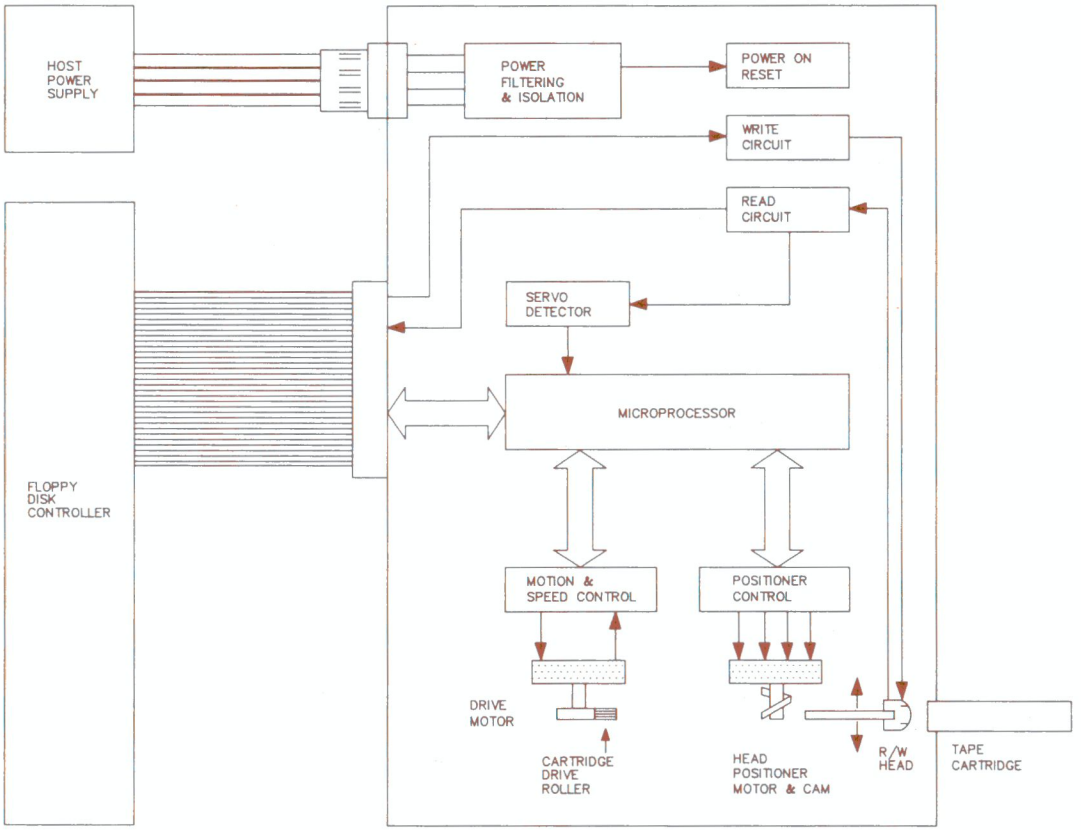

Figure 12-2. Fixed Disk Drive Backup (Tape Drive) Functional Block Diagram

12.2 SPECIFICATIONS

Table 12-1 lists the physical and electrical specifications of the fixed disk drive backup systems.

Table 12-1. 40-Megabyte and 10-Megabyte Fixed Disk Drive Backup Systems Physical and Electrical Specifications

	40-Megabyte Fixed Disk Drive Backup		10-Megabyte Fixed Disk Drive Backup
Size:			
Width	5.65 in. (144 mm)		Same
Height	1.65 in. (41 mm)		Same
Depth	8.00 in. (203 mm)		Same
Weight	1.7 lb (0.77 kg)		Same
Formatted capacity (with ECC)	40.63 megabyte		10.35 megabyte
Flux reversal density	10000 FRI		6400 FRI
Data-transfer rate	500 kb/s		250 kb/s
Head positioning time:			
Adjacent tracks	250 ms		Same
Move (worst case)	1 sec		Same
Tape speed:			
Read/write	50 in./s		39 in./sec
Rewind/fast forward	70 in./s		70 in./sec
Tape end-to-end positioning time:	DC 1000 (see Note 1)	DC 2000	DC 1000 (see Note 2)
Read/write	44 sec	49 sec	57 sec
Forward/reverse	31 sec	35 sec	31 sec
Track density	83 TPI		59 TPI
Number of tracks	20		8
Blocks/track	124		158
Sectors/block	18 (2 for ECC)		8
Bytes/sector	1024		1024

Notes: 1. The 10-megabyte fixed disk drive backup uses DC 1000 tape cartridges (supported on other COMPAQ products) which can be read by the 40-megabyte fixed disk drive backup. The 40-megabyte fixed disk drive backup cannot write to a DC 1000 tape cartridge.

2. DC 2000 tape cartridge does not physically fit into a 10-megabyte fixed disk drive backup.

12.3 FIXED DISK DRIVE BACKUP COMMANDS

All fixed disk drive backup operations are one of five fundamental processes:

1. Servo-Write, which initializes the tape media by writing indexing information.
2. Tape Format, which writes block, sector, and track information onto the tape. This information joins the indexing information previously written by Servo-Write. This process prepares data areas consistent with the NEC765A diskette controller data format.
3. Write-Data, which writes information in the same layout as standard diskette tracks.
4. Read-Data, which reads information in the same layout as diskette tracks.
5. Erase, which erases all information on tape, including servo and data information. (Supported only on the 40-megabyte fixed disk drive backup.)

The Servo-Write operation is initiated by executing an Enter Format Mode command followed by the Servo-Write command. This action moves the tape to the beginning, at block 0 and head 0 and then writes encoding index pulses on the tape in a streaming-write mode. These pulses are used solely by the fixed disk drive backup and are not available to the programmer.

NOTE: If the Servo-Write operation is interrupted, the tape cartridge must be fully erased before it can be used again.

The format operation for tape is similar to the format process for diskette drives. To format the tape, the multipurpose controller board takes control of the interface and supplies the track and sector data for every block on the track. The data format on the tape has the characteristics of a diskette.

The fixed disk drive backup systems accept commands from the multipurpose controller board as pulses on the step line. The number of pulses determines the desired command. Any number of pulses not recognized as commands are ignored. The fixed disk drive backup does not recognize the step pulses unless the 765A is programmed for a 3- or 6-ms gap between pulses. Table 12-2 lists the fixed disk drive backup commands.

Table 12-2. Fixed Disk Drive Backup Command Summary

Step Pulses	Command	Action
2	Stop Motion	Stops tape - deactivates BUSY- signal.
3	Pause	Moves tape back two blocks - stops tape.
4	Seek Load Point	Rewinds tape at 50 IPS and goes to track 0.
5	Move Tape Forward	Moves tape forward at 70 IPS (fast forward).
6	Move Tape Back	Moves tape backward at 70 IPS (rewind).
7	Report Normal Completion	Latches BUSY- line if latest command has successfully completed.
8	Report Drive Present	Latches BUSY- line if selected.
9	Report End	Latches BUSY- line if at end of tape.
10	Report Begin	Latches BUSY- line if at tape beginning.
11	Report Cart	Latches BUSY- line if cartridge is present.
12	Report Track Found	Latches BUSY- line if track seek has completed.
13	Report New Cartridge	Latches BUSY- line if cartridge has been replaced.
14	Move Tape Against Data	Moves tape at 50 IPS (or 39 IPS if in low-density mode) toward file beginning.
15	Move Tape With Data	Moves tape at 50 IPS (or 39 IPS if in low-density mode) toward file end.
16	Enter Format Mode	Produces index pulses at end and beginning of data area to allow formatting by the 765. The drive must be in the Format mode to enable subsequent execution of the Servo Write command.
17	Enter Normal Mode	Produces index pulses at beginning of data area.
18 *	Report Expanded Instruction Set	Pulses the BUSY- line if it supports the Expanded command set (commands 19, 28, and 29.)
19 *	Report Drive/Cartridge Type	Pulses the BUSY- line. The controller responds with "N" step pulses to inquire about a specific status condition.
20	Seek Track 0	Initiates tape motion and seeks track 0.
21	Seek Track 1	Initiates tape motion and seeks track 1.
22	Seek Track 2	Initiates tape motion and seeks track 2.
23	Seek Track 3	Initiates tape motion and seeks track 3.
24	Seek Track 4	Initiates tape motion and seeks track 4.

* These commands are not available with the 10-megabyte fixed disk drive backup.

(Continued)

Table 12-2. (Continued)

Step Pulses	Command	Action
25	Seek Track 5	Initiates tape motion and seeks track 5.
26	Seek Track 6	Initiates tape motion and seeks track 6.
27	Seek Track 7	Initiates tape motion and seeks track 7.
28 *	Seek Track "N"	Pulses BUSY- line. The controller responds with "N" step pulses.
29 *	Erase Tape	Erases entire tape.
31	Servo Write	Writes servo pattern on blank cartridge. The drive must be in Format mode.
32	Recalibrate	Sends simulated "at track 0" status to multipurpose controller board for diskette drive compatibility.

* These commands are not available with the 10-megabyte fixed disk drive backup.

Command 19 causes the drive to pulse the BUSY- line. The controller responds with "N" pulses to inquire for a specific status condition. Table 12-3 gives the pulses used for the various status conditions. Command 19 is not available with the 10-megabyte fixed disk drive backup.

Table 12-3. BUSY- Line Pulses for Status

"N" Step Pulses	Status Condition	Drive BUSY- Response	Status
4	Cartridge Type	Low	DC 2000 cartridge in drive.
		High	DC 1000 cartridge in drive.
5	Servo Density	Low	High-density, servo written, transfer rate at 500 kHz, R/W speed at 50 IPS.
		High	Low-density, servo written or blank cartridge. Transfer rate at 500 kHz, R/W speed at 39 IPS.
6	Drive Type	Low	40-Megabyte fixed disk drive backup.
		High	10-Megabyte fixed disk drive backup.

12.4 CONNECTORS

The fixed disk drive backup systems use the same cable, connectors, and pin arrangements as the diskette drives for the connections to the multipurpose controller board or multipurpose fixed disk controller board and the DC power supply.

The signal functions are different, however, and special software drivers are used to control the fixed disk drive backup systems. Table 12-4 shows the signal functions.

Table 12-4. Drive Logic Board to Drive Controller Signal Descriptions

Signal Name	Function
DRIVE 4 (TAPE) SELECT-	Drive select 4 is used to select 40-megabyte fixed disk drive backup.
INDEX-	Indicates to the multipurpose controller board that one block has passed.
READ DATA-	This is the data stream of data and clock pulses from the 40-megabyte fixed disk drive backup.
STEP-	Pulses give commands to the fixed disk drive backup.
BUSY-	Indicates to the multipurpose controller board that the fixed disk drive backup is still executing a command.
WRITE DATA-	This stream of data is written to the tape when WRITE GATE- is enabled.
WRITE GATE-	Enables the drive-logic disk-write circuits so data from the WRITE DATA- signal is written.
WRITE PROTECT-	Indicates to the multipurpose controller board that the cartridge in the drive is write-protected.

Figures 12-3 and 12-4 show the fixed disk drive backup system connectors.

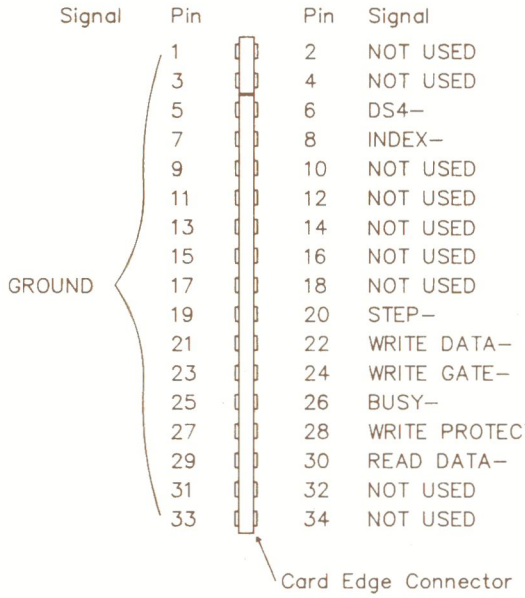

Figure 12-3. Fixed Disk Drive Backup Connector Pinout

Figure 12-4. Fixed Disk Drive Backup Power Connector Pinout

12.5 TAPE FORMAT

The tape utility begins formatting with a Servo-Write process. The Servo-Write process divides the tape into sections called servo-blocks. Table 12-5 lists the track and sector sizes for the DC 1000 and DC 2000 tape cartridges.

Table 12-5. Tape Track/Sector Sizes

Tape Cartridge	DC 1000	DC 2000
Number of tracks	8	20
Number of blocks/track	158	124
Number of sectors/block	8 (Note 1)	18 (Note 2)
Number of bytes/sector	1024	1024

Notes: 1. Xenix uses two sectors for ECC, leaving 6 data sectors.
2. Two sectors are ECC, leaving 16 data sectors available.

The tape utility then writes format data into the servo-blocks. Each of the tape tracks is formatted by the NEC765A diskette controller to yield a specific number of 1024-byte sectors per block. The data is written in double-density or modified frequency modulation (MFM) with the same layout as a standard diskette track. Table 12-6 gives the data format for the tape.

Table 12-6. Tape Data Format

	Nominal Value(hex)	Number of Bytes
(Index pulse) Pre-index Gap	4E	80
Pre-index Address Mark Sync	00	12
Index Address Mark	FC(Note 1)	4
Gap 1	4E	50
Pre-ID AM Sync	00 (Note 2)	12
ID Address Mark	FE (Note 2)	4
Sector ID	xx (Note 3)	4
Sector ID CRC	xx (Note 3)	2
Gap 2	4E	22
Pre-Data AM Sync	00	12
Data Address Mark	FB (Note 2)	4
Data	xx (Note 3)	1024
Data CRC	xx	2
Gap 3	4E	54
Gap 4	4E	(until second index pulse)

Notes: 1. First 3 bytes are C2 with missing clock transition between bits 3 and 4.
2. First 3 bytes are A1 with missing clock transition between bits 4 and 5.
3. xx = data dependent.

The Gap 3 value (54 bytes) shows the gap size when the tape is formatted. The Gap 3 size specified in the read/write commands is smaller (23 bytes). The size of Gap 4 depends on the tape speed. The NEC765A keeps writing until the second index pulse occurs.

The boxed field of Table 12-5 is written once for each sector in the block, with appropriate sector ID values for each sector written. The sector ID consists of four 1-byte fields that are used to identify each sector (using diskette mnemonics):

CYL	HEAD	SECT	SIZE	(CRC)	(CRC)

40-megabyte fixed disk drive backup:

```
Cylinder = 0..123  Tape block number
Head     = 0       (Not used)
Sector   = 1..18*  Sector number (within tape block)
Size     = 3       Sector size (3 denotes 1024 bytes)
```

*Two sectors are for ECC, 16 data sectors are available.

10-megabyte fixed disk drive backup

```
Cylinder = 0..157  Tape block number
Head     = 0       (Not used)
Sector   = 1..8    Sector number (within tape block)
Size     = 3       Sector size (3 denotes 1024 bytes)
```

12.6 TAPE UTILITIES

Compaq provides TAPE Utilities to use with the fixed disk drive backup systems. These utilities make the 10-megabyte and the 40-megabyte fixed disk drive backup systems available to both MS-DOS and XENIX users.

This section provides information on the data format used by the COMPAQ TAPE Utilities. This description includes the tape header information, tape identification area, save set descriptions, file allocation table, and directory and file information. The section entitled "XENIX File Storage," at the end of the chapter, provides XENIX-specific information.

The 10-megabyte fixed disk drive backup uses only a DC 1000 tape cartridge. The 40-megabyte fixed disk drive backup can accept either a DC 1000 or DC 2000 tape cartridge. Some differences in the support between the two drives reflects this difference in tape cartridges.

MS-DOS File Storage

The format of the data depends on the Tape Utility used to write the data to the tape. This section discusses the format of data written to the tape, DC 1000 and DC 2000, using COMPAQ TAPE Utilities.

Two versions of COMPAQ TAPE Utility exist. Tape Utility Version 1 supports only the 10-megabyte fixed disk drive backup. Tape Utility Version 2 supports both the 10-megabyte and the 40-megabyte fixed disk drive backup, and can read data from a 10-megabyte tape backed up with Tape Utility Version 1.

The COMPAQ TAPE Utilities place a tape header (HDR) and a file allocation table (FAT) at the beginning of the tape (Track 0, Block 0).

When a set of files is written to the tape, the HDR and the FAT are modified to reflect the new tape status. A redundant copy of the HDR and FAT is stored in Track 0, Block 1. If the first block becomes unreadable, the information in the second block is used to retrieve the data on the tape. All remaining blocks contain directory and file information.

COMPAQ TAPE Utility, Version 2 generates an error correction code (ECC) when writing to a DC 2000 tape. The ECC is stored in the last two sectors of each block. Figure 12-5 shows the format of the blocks.

Block	Sector 1	2	3	...	15	16	17	18
0	HDR	FAT	FAT	...	FAT	FAT	ECC	ECC
1	HDR	FAT	FAT	...	FAT	FAT	ECC	ECC
2	FILES	...	...	...	...	...	ECC	ECC
.								
.								
.								

Figure 12-5. MS-DOS Track 0 Format (DC 2000 tape)

Figure 12-6 shows the format for Track 0 data without ECC. No ECC is generated by Tape Utility Version 2 when used with a 10-megabyte fixed disk drive backup.

Block	Sector 1	2	3	4	5	6	7	8
0	HDR	FAT	FAT	FAT	(FAT)	(FAT)	(FAT)	(FAT)
1	HDR	FAT	FAT	FAT	(FAT)	(FAT)	(FAT)	(FAT)
2	FILE	...						
.								
.								
.								

Figure 12-6. MS-DOS Tape Track 0 Data (DC 1000 tape)

Tape Header

The tape header (HDR) occupies the first 1024-byte sector on the tape. The tape header is divided into several sections, the Tape Identification area (TID), the Save Set Description, and a reserved area. Figure 12-7 provides a summary of the tape header format.

COMPAQ TAPE Utility	TID	Save Set Description	Reserved
MS-DOS, Version 1	64 Bytes	N/A	960 bytes
MS-DOS, Version 2	64 Bytes	768 bytes	192 bytes

Figure 12-7. MS-DOS Tape Header

Tape Identification Area

Table 12-7 lists the contents of the Tape Identification area. Table 12-8 further explains the contents of the Tape Identification area.

Table 12-7. Tape Identification Area

Address	Function	COMPAQ TAPE Utilities Bytes
0	Reserved (must be zero)	2
2	Volume name	32
34	Create (format) time	2
36	Create (format) date	2
38	Tracks per tape	2
40	Blocks per track	2
42	Sectors per block	2
44	Bytes per sector	2
46	Tape number	2
48	More flag (for multiple-tape backup)	2
50	Backup time	2
52	Backup date	2
54	Program version (in BCD)	2
56	Format type	2
58	Reserved	6

Table 12-8. Tape Identification Area Parameters

Parameter Name	Description
Volume name	Up to 31 characters in length, padded with zeros to 32 bytes, resulting in a 'standard' null-terminated string
Date/time the tape was initialized	Set only when the tape is formatted (by TAPE FORMAT or TAPE BACKUP), and is not updated by a normal BACKUP operation. (See Figure 12-8)
Number of tracks per tape	20 for 40-megabyte tape, numbered 0..19, 8 for 10-megabyte tape, numbered 0..7
Number of intra-servo blocks per tape track	124 for 40-megabyte tape, numbered 0..123, 158 for 10-megabyte tape, numbered 0..157
Number of sectors per block	18 for 40-megabyte tape, numbered 1..18, 8 for 10-megabyte tape, numbered 1..8
Number of bytes per sector	1024
Tape number	The number of this tape in a multiple-tape backup set. For a single-tape backup, this entry is 1
More flag	This word is set to 1 to indicate that there are additional tapes in the backup set, or 0 to indicate that this is the last tape in the set. For a single tape backup, this entry is 0
Date/time	The Date/time is written by BACKUP when the tape was backed-up and updated. (See Figure 12-8)
Tape utility version (in BCD)	The version of the COMPAQ TAPE Utility that wrote the tape 0000h = Tape Utility before Version 1.10 0100h = TAPE Utility Version 1.1 020h = TAPE Utility Version 2.0
Format Descriptor	The low byte of this word appears at offset +56 in the first sector of the tape. The format descriptor is used by the software to determine the tape format by recognizing the following codes: 0 - Tape is unused 1 - Reserved 2 - Reserved 3 - Tape used by COMPAQ TAPE Utility prior to version V1.10 4 - Tape used by COMPAQ TAPE Utility version V1.10 and later

Figure 12-8 shows the format of the time and date parameters of the Tape Identification area.

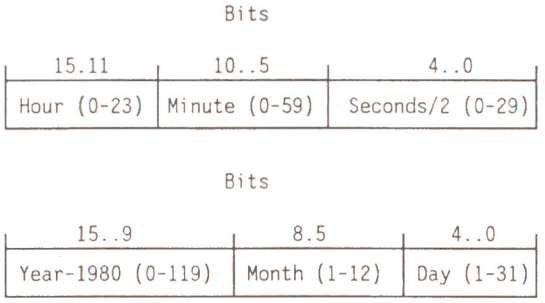

Figure 12-8. Date and Time Format

Save Set Descriptions

The COMPAQ TAPE Utility Version 2 supports multiple backups per tape. (This feature does not apply to COMPAQ TAPE Utility Version 1.) Each time a set of files is backed up to the tape, a save set description containing 24 bytes is written to the tape header. Up to 32 save set descriptions can be stored in the 768-byte save set description area of the tape header. Table 12-9 lists the 24-byte save set parameters.

Table 12-9. Save Set Description

Function	Bytes
Backup time	2
Backup date	2
Version	2
Save Set label	12
Start block	2
Source drive	1
Reserved	3

Table 12-10 further explains the contents of the save set description.

Table 12-10. Save Set Description Parameters

Parameter Name	Description
Backup time/date	Time/date the save set was backed up. This entry in the last nonblank save set matches the backup time and data located in the TID area.
Tape Utility Version (in BCD)	The version of the COMPAQ TAPE Utility that wrote the save set.
Starting block of Save Set	Tape block number where the save set begins.
Backup source drive	Fixed disk or diskette drive from which the save set was backed up.
Save Set label	Save set label, up to 11 characters in length. padded with zeros to 12 bytes, resulting in a standard null-terminated string.

File Allocation Table

The file allocation table (FAT) controls the assignment of sectors on the tape. For every sector on the tape, except for sectors containing ECC information, 2 bits are maintained in the FAT that describe the current state of that sector:

FAT Entry	Sector Status
0 0	Not allocated
0 1	Start of a file (header)
1 0	Allocated
1 1	Bad sector

Each FAT byte contains four 2-bit fields, with the least-significant bits describing the first sector. The FAT has allocation entries for the entire tape, including the tape HDR and FAT sectors. The entries for these sectors are "allocated."

Not all 15 available sectors on a DC 2000 tape cartridge are used for the FAT (not all are necessary).

The size (in bytes) of the FAT for a tape can be determined by the following formula:

(Tracks x blocks per track x sectors per block x bits per sector)/8 bits per byte

The size (in bytes) of the FAT for a DC 1000 tape can be determined by the following formula:

(8 tracks x 158 blocks per track x 8 sectors per block x 2 bits per sector)/8 bits per byte.

Example: A DC 1000 tape with no bad blocks contains two files, one which occupies one sector, and one which occupies three sectors. The first 6 bytes of the FAT would appear as follows:

FAT entries for first block on tape:

10101010	10101010
AA	AA

FAT entries for second block on tape:

10101010	10101010
AA	AA

FAT entries for files:

10100101	00000000
A5	00

For a DC 2000 tape, the FAT table is:

(20 tracks x 124 blocks per track x 16 sectors per block x 2 bits per sector)/8 bits per byte = 39680/4 or 9920 bytes/FAT

Example: A DC 2000 tape with no bad blocks contains two files, one which occupies 1 sector, and one which occupies 3 sectors. The first 10 bytes of the FAT would appear as follows:

FAT entries for first block on tape:

10101010	10101010	10101010	10101010
AA	AA	AA	AA

FAT entries for second block on tape:

10101010	10101010	10101010	10101010
AA	AA	AA	AA

FAT entries for files:

10100101	00000000
A5	00

Directory Information

When writing data to a tape using COMPAQ TAPE Utility Version 2, all blocks after 0 and 1 on track 0 contain directory and file information. This section on directory information does not apply with COMPAQ TAPE Utility Version 1. If the backup spanned multiple directories, the first sector(s) of the save set contain directory information. This information tells the COMPAQ TAPE Utility which directories to create on the destination disk during the tape restore process. These sectors are marked as allocated in the FAT.

Table 12-11 lists the format of the directory information.

Table 12-11. Directory Information

Function	Bytes
Directory name 1	78
Last entry flag	2
Reserved for future use	2
.	
.	
.	
Directory name x	78
Last entry flag	2
Reserved for future use	2

Table 12-12 lists the directory information parameters.

Table 12-12. Directory Information Parameters

Parameter Name	Description
Directory name	Directory pathname, padded with zeros to 78 bytes, resulting in a standard null-terminated string
Last entry flag	End of the directory name list. This word is set to A if this is the last entry in the directory. If this is not the last entry, this word is 0.
Reserved	

Only the pathnames of the lowest level subdirectories are saved. All intermediate subdirectories can be recreated from these.

Example: The following directory names are generated for the directory shown in Figure 12-9:

```
\DOS
\TOOLS\EDITOR
\MISC\REPORTS\TEMP
\MISC\MEMOS
\MISC\EXPENSE
```

Figure 12-9. Sample Directory

File Information

Following the directory information (if any) are the sectors containing the file information.

The first sector of each file contains a header, which contains various information about the file.

Table 12-13 describes the file information.

Table 12-13. File Information

Function	Bytes
Header Signature (AAh,55h)	2
Filename	108
File Attribute	2
Original File Time	2
Original File Date	2
File Size (in bytes)	4
Backup Time	2
Backup Date	2
Aux File Attribute #1	2
Aux File Attribute #2	2

The file information parameters are given in Table 12-14.

NOTE: Any empty sectors in the last block of a save set are marked as allocated in the FAT.

Table 12-14. File Information Parameters

Parameter Name	Description
Header Signature	The 2-byte header signature is AAh, 55h. This signature is used to identify the header or separate it from the rest of the tape information.
Filename	The filename may be up to 107 characters in length, padded with zeros to 108 bytes, resulting in a standard null-terminated string. There is no structure imposed on the filename other than maximum length, but the COMPAQ TAPE Utility expects a DOS-style pathname (without a drive letter).
File Attribute	This word value is used by the COMPAQ TAPE Utility to retain the original attributes of the file as specified by the operating system. For MS-DOS, only the low-order byte is used.
Original Date/time	Original date/time of the file. (See Figure 12-3 for format)
File Size	32-bit file size (in bytes)
Backup Time and Date	The date and time the file was backed up. This value is the same as the corresponding value in the headers of all the other files that were part of the same backup .
Aux File Attribute #1	Not used in COMPAQ TAPE Utility prior to version 1.10. In version 1.10 and later: Bit 0, if set (=1), means that this file is continued on the next tape. In this case, the file size indicates only the portion of the file that is on this tape. Bit 1, if set (=1), means that this file is continued from the previous tape. In this case, the file size indicates only the portion of the file that is on this tape. If bit 1 is set (=1), with bit 0 reset (=0), this is the last portion of the file.
Aux File Attribute #2	Reserved, must be 0.

XENIX File Format

The XENIX tape support is implemented as a true device driver, /dev/mt0. The XENIX manual Volume M discusses this driver in the section entitled mt(M). The Xenix utilities traditionally associated with backing up data (tar, cpio, backup, restore, and dd) access the fixed disk drive backup through the standard XENIX file system interface, /dev/mt0. Refer to the XENIX manual Volume C for complete information on these utilities. The device driver provides these utilities with memory buffer management, tape Error Correction Code (ECC), and all necessary fixed disk drive backup control.

The XENIX tape device driver supports both the 10-megabyte and the 40-megabyte fixed disk drive backup systems. The device driver uses basically the same physical tape format as the COMPAQ TAPE Utilities. The following section describes the specific use of Track 0, Block 0. This physical format is only for the use of the device driver, the utilities never access the header blocks or the ECC information.

Track 0, Block 0 contains the tape format and ECC information. Sector 1, the heading sector (HDR), has the same layout as the MS-DOS HDR. The HDR information includes the four bytes (Tape Identification (TID) area bytes 54 and 56) that indicate a XENIX formatted tape and provide the version number of the XENIX driver. The remainder of the sector is not used by XENIX. Sector 2 contains the Bad Block Table (BBT). The BBT contains the absolute tape block numbers for the unusable blocks. This table is described fully in the section entitled "Bad Block Table," later in this chapter. The specific location of the ECC information varies for the DC 1000 and the DC 2000 tapes, but it is always in the last two sectors of Track 0, Block 0. For the DC 1000, Sectors 7 and 8 contain the ECC. For the DC 2000, Sectors 17 and 18 contain the ECC. For both tapes, the sectors between the BBT and the ECC are unused. (Sectors 3 through 6 for DC 1000 and Sectors 3 through 16 for DC 2000.)

Figures 12-10 and 12-11 show the format for Track 0 of a XENIX formatted tape.

Block	Sector 1	2	3	4	5	6	7	8
0	HDR	BBT	R E	S E	R V	E D	ECC	ECC
1	1	2	3	4	5	6	7	8
2	9	10	11	12	13	14	15	16
3	ECC	ECC	17	18	19	20	21	22
4	23	24	25	26	27	28	29	30
5	31	32	ECC	ECC	...	...	...	...

Figure 12-10. XENIX Track 0 Format (DC 1000 tape)

Block	Sector 1	2	3	4	...	16	17	18
0	HDR	BBT	R E	S E	R V	E D	ECC	ECC
1	1	2	3	4	...	16	ECC	ECC
2	17	18	19	20	...	32	ECC	ECC
.	...	...	...	...	...	...	ECC	ECC

Figure 12-11. XENIX Track 0 Format (DC 2000 tape)

XENIX Tape Operations

The tape must be formatted before data can be written on it. For more information on the XENIX format command, refer to the XENIX manual Volume M, the section entitled "format(M)". The format command takes approximately 38 minutes for a new tape. The first 19 minutes are for the servo-write. (This operation should not be interrupted.) The next 19 minutes are for the bad block mapping.

To ensure streaming during reads or writes, the XENIX tape device driver uses a large buffer to collect the data, making the tape operations as uninterrupted as possible. The driver dynamically allocates kernal data to be used as the large data buffer. The driver must be able to allocate two 72-Kbyte buffers (144 Kbytes of RAM buffer space) before allowing an OPEN on the tape file to succeed. For the 40-megabyte fixed disk drive backup, the driver must be able to allocate three 18-Kbyte buffers (54 Kbytes). Insufficient RAM causes an error message and the read or write fails.

Bad Block Table

The XENIX TAPE Utility designates Sector 2 of Block 0 as the XENIX specific Bad Block Table. Unusable blocks are entered by storing the absolute tape block number in the table. The table is a variable length list with a maximum of 252 entries. The list is terminated by a -1. Entry 255 is a signature, AAh, 55h, and entry 256 is a checksum.

Figure 12-12 illustrates the Bad Block Table Structure.

Sector 2, Track 0 Byte Number	Bad Block Table Entries
0	Bad Block Entry 1
2	Bad Block Entry 2
	:
1016	Bad Block Entry 252
1018	-1
1020	Signature (AAh, 55h)
1022	Checksum

Figure 12-12. Bad Block Table, XENIX Tape Utility

Chapter 13
MONITORS

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MONITORS

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Chapter 13
MONITORS

13.1 COMPAQ® DUAL-MODE MONITOR

COMPAQ monitors have the following features:

- Dual-mode capability
- Amber and green screen available (external monitors only)
- 12-volt DC operation

The COMPAQ Dual-Mode monitors are capable of displaying in either the high-resolution text mode or the graphics mode with the same monitor. Mode selection is accomplished via the COMPAQ Video Display Controller Board by changing the monitor scan rates. The COMPAQ Video Display Controller Board changes the scan rates in response to software interrupts (See Chapter 7) or to multiple-key commands from the keyboard (See Chapter 8).

The COMPAQ PORTABLE 286® has an internal dual-mode monitor that is internally connected to the COMPAQ Video Display Controller Board. The COMPAQ Dual-Mode Monitor is an external monitor which may be used with the COMPAQ DESKPRO 286 or, optionally, with the COMPAQ PORTABLE 286.

Figures 13-1 and 13-2 show the COMPAQ Dual-Mode Monitors.

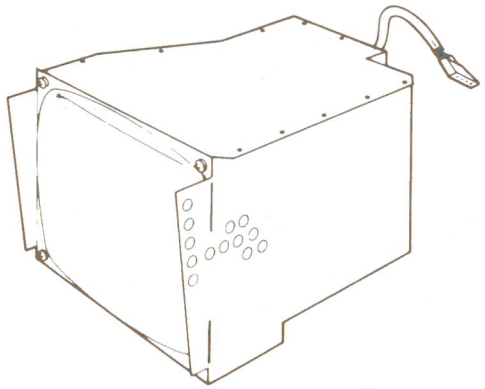


Figure 13-1. COMPAQ PORTABLE 286 Dual-Mode Monitor

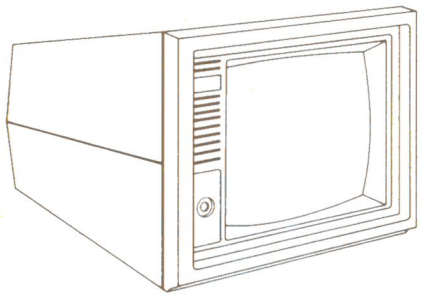


Figure 13-2. COMPAQ Dual-Mode Monitor

Figures 13-3 and 13-4 show the monitors' functional block diagrams.

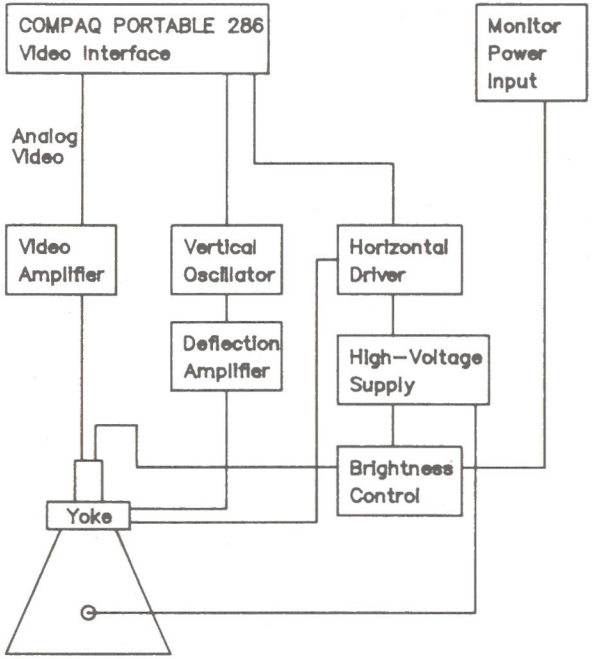


Figure 13-3. Functional Block Diagram for COMPAQ PORTABLE 286 Monitor

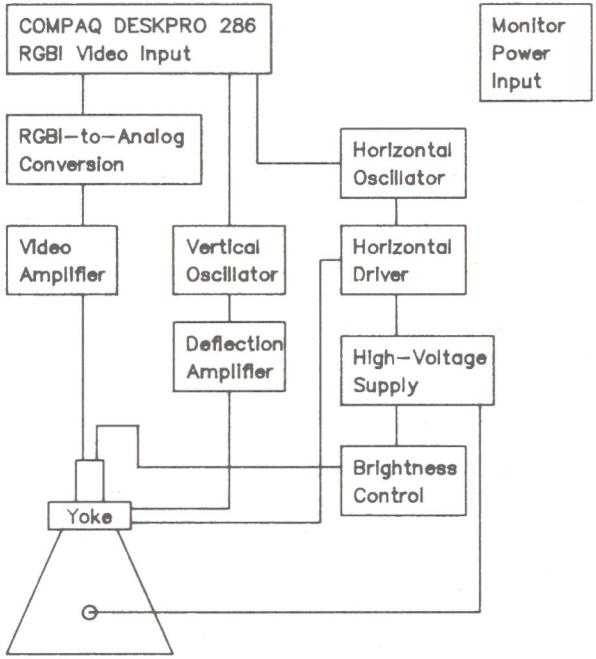


Figure 13-4. Functional Block Diagram for COMPAQ DESKPRO 286 Monitor

COMPAQ Dual-Mode Monitor Specifications

Table 13-1 lists the monitor specifications.

Table 13-1. COMPAQ Dual-Mode Monitor Specifications

	COMPAQ PORTABLE 286	COMPAQ DESKPRO 286
Screen:		
CRT size	9 in. diagonal	12 in. diagonal
Phosphor	Green, medium persistence	Green, medium persistence or Amber, medium persistence
Active area (see Figure 13-5)		
Horizontal	6.3 in. (16.0 cm)	8.1 in. (20.6 cm)
Vertical	4.6 in. (11.7 cm)	6.0 in. (15.2 cm)
Power Requirements:		
Voltage	12.3 Vdc, ±4%	12.4 Vdc, ±4%
Current	1.5 A max, 2.0 A surge (5 ms)	1.8 A max, 2.5 A surge (10 ms)
Signals:		
Video	Analog, 1.0 to 2.5 V into 470 ohms min.	Digital, TTL-level RGBI yielding a 15-level gray scale
Horizontal Sync	Positive, TTL-level	Positive, TTL-level
Vertical Sync	Negative, TTL-level	Positive, TTL-level
Connectors:		
Power	6-pin single row, AMP 102409-5, or equiv.	3-pin male circular DIN AMP 211502-5, or equiv.
Signal	12-pin double row, AMP 87227-6, or equiv.	9-pin male subminiature D

Figure 13-5 shows the active area on the screen.

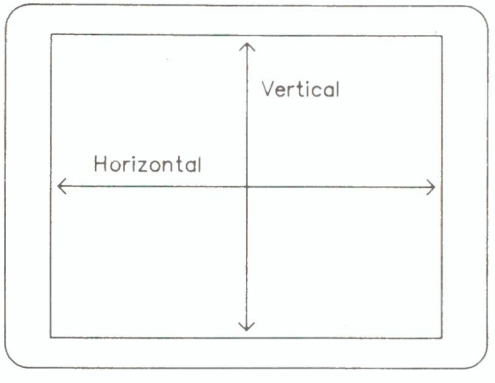


Figure 13-5. Screen Active Area

Table 13-2 lists the monitor resolution (pixel density) and frequency for the high-scan and low-scan modes.

Table 13-2. Monitor Resolution and Frequencies

Scan Mode	Mode Signal	Resolution (in pixels)	Horiz. Freq.	Vert. Freq.
High-Scan	LOW	720 x 350	18.5 KHz	50 Hz
Low-Scan	HIGH	640 x 200	15.7 KHz	60 Hz

Table 13-3 lists the Safety Compliances for the monitors.

Table 13-3. COMPAQ Dual-Mode Monitor Safety Compliances

Safety	UL 1418 UL 478 DHHS 21 CFR Subchapter J CSA 22.2 #154 VDE or TUV in accordance with DIN IEC 380/VDE 806
RFI	
U S	FCC Class B
International	VDE 0871 Level B (See Note)

Note: Units shipped internationally comply with this regulation and include COMPAQ part numbers 102508-3, green phosphor, international and 102508-4, amber phosphor, international.

COMPAQ Dual-Mode Monitor Waveforms

References to the red, green, blue, and intensity signals in the COMPAQ Video Display Controller Board translate to variations in intensity on COMPAQ monochrome monitors by assigning a weighted value to each signal. Figures 13-6 through 13-8 show the timing parameters for the monitors.

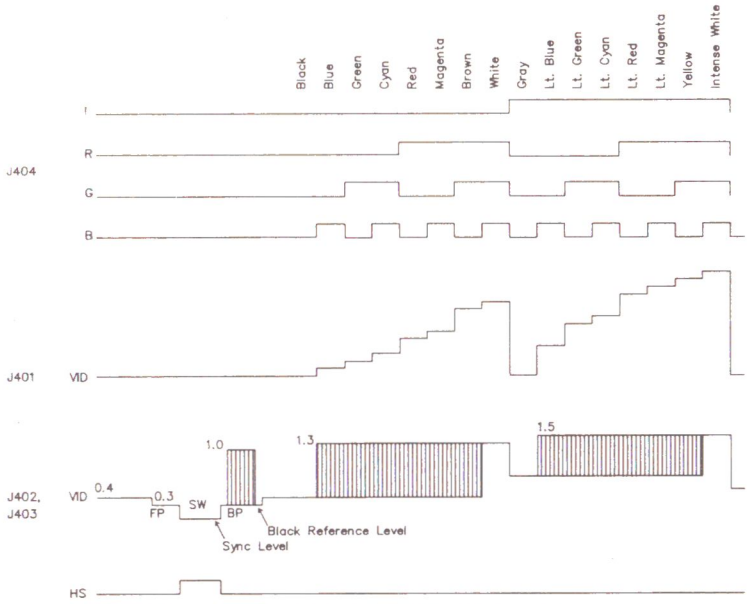


Figure 13-6. COMPAQ Dual-Mode Monitor Video Timing Waveforms

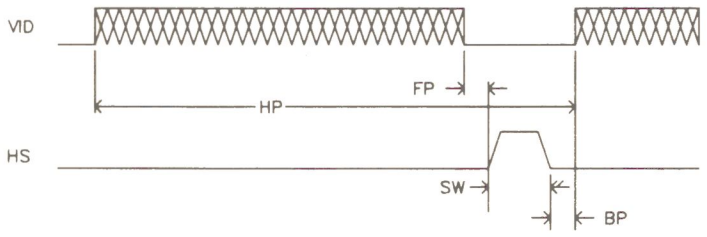


Figure 13-7. COMPAQ Dual-Mode Monitor Horizontal Timing

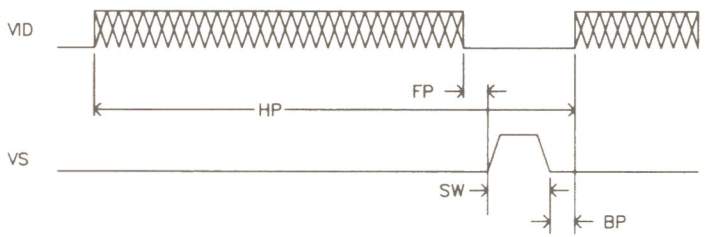


Figure 13-8. COMPAQ Dual-Mode Monitor Vertical Timing

COMPAQ Dual-Mode Monitor Connectors

The COMPAQ PORTABLE 286 Dual-Mode Monitor signal cable connects to the COMPAQ Video Display Controller Board connector J401 (connector J401 is an internal connector). The COMPAQ PORTABLE 286 monitor-power cable connects to the system board connector J112. Figure 13-9 and Table 13-4 describe the monitor signal connector. Figure 13-10 shows the monitor power connector.

The COMPAQ Dual-Mode Monitor signal cable connects to the COMPAQ Video Display Controller Board RGBI connector (J404). The COMPAQ Dual-Mode Monitor power cable connects to the monitor power receptacle. These connectors are on the back of the system unit. Figure 13-11 and Table 13-5 describe the monitor signal connector. Figure 13-12 shows the monitor power connector.

Table 13-4. COMPAQ PORTABLE 286 Monitor Signal Connector

Signal	Pin	I/O	Description
Chassis ground	11,12	-	Cable Shield.
HS	7	I	Horizontal sync is an active-high TTL signal in both level and drive characteristics. Refer to the Waveforms section for the horizontal sync signal timing characteristics.
MODE	3	I	The mode signal (TTL) indicates whether the monitor should be in the high- or low-scan mode. During a mode change, both horizontal and vertical sync are suppressed for up to 16 vertical frames. The mode signal is high (logic 1), for the low-scan mode, and low (logic 0) for the high-scan mode.
Signal ground	2,4,8	-	This is the ground reference for the TTL signals.
VID	5	I	This is the analog video output signal. The signal voltage ranges from 1.0 volts (black) to 2.5 volts (white) into 470 to 6800 ohms (impedance). This signal is referenced to the video signal ground (pin 6).
Video ground	6	-	This is the ground reference for the VID signal (pin 5).
VS-	1	I	Vertical sync is an active-low TTL signal in both level and drive characteristics. Refer to the Waveforms section for the vertical sync signal timing characteristics.

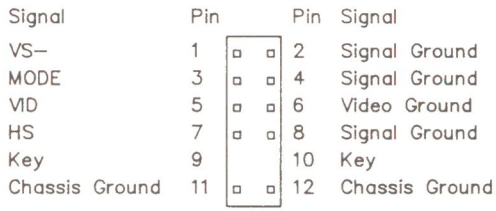


Figure 13-9. COMPAQ PORTABLE 286 Dual-Mode Monitor Signal Connector

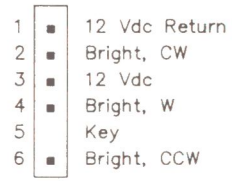


Figure 13-10. COMPAQ PORTABLE 286 Dual-Mode Monitor Power Connector

Table 13-5. COMPAQ Dual-Mode Monitor Signal Connector

Signal	Pin	I/O	Description
B	5	I	Blue, active-high TTL video signal.
G	4	I	Green, active-high TTL video signal.
HS	8	I	Horizontal sync is an active-high TTL signal in both level and drive characteristics. Refer to the waveform section for the timing characteristics.
I	6	I	Intensity, active-high TTL video signal
MODE	7	I	The mode signal controls the monitor high- or low-scan mode. During a mode change, both horizontal and vertical sync are suppressed for up to 16 vertical frames. The mode signal is high for the low-scan mode and low for the high-scan mode.
R	3	I	Red, active-high TTL video signal.
Signal Ground	1,2	-	TTL signal reference.
VS	9	I	Vertical sync is an active high TTL signal in both level and drive characteristics. Refer to the waveform section for the timing characteristics.

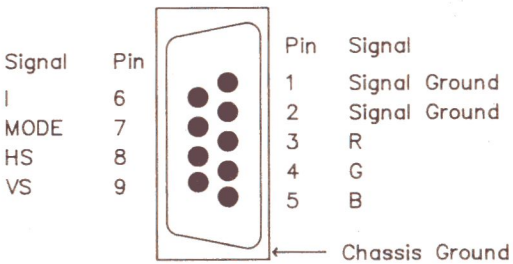


Figure 13-11. COMPAQ Dual-Mode Monitor Signal Connector

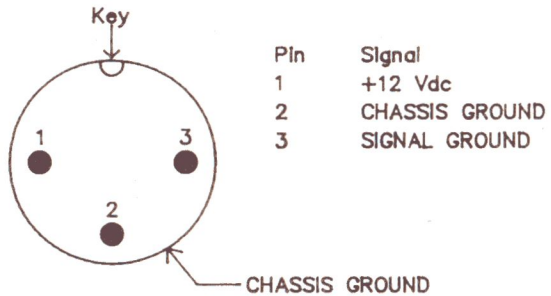


Figure 13-12. COMPAQ Dual-Mode Monitor Power Connector

13.2 COMPAQ COLOR MONITOR

The COMPAQ Color Monitor, shown in Figure 13-13, is a dual-frequency, high-quality color monitor. This monitor is compatible with the COMPAQ Enhanced Color Graphics Board and the COMPAQ Video Display Controller Board. With the COMPAQ Enhanced Color Graphics Board the monitor can display up to 64 colors, using a 6-bit color definition.

The dual-frequency feature allows the monitor to function at two horizontal frequencies. The 15.7 kHz horizontal sweep frequency generates 200 visible (or active) scan lines per vertical frame. The 21.8 kHz horizontal sweep frequency generates 350 visible (or active) scan lines per vertical frame.

Figure 13-14 is a functional block diagram of the COMPAQ Color Monitor.

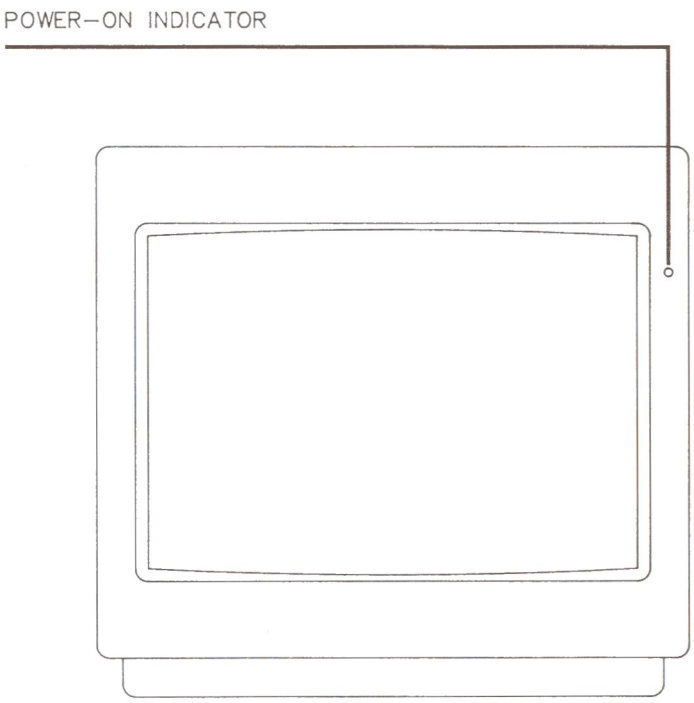


Figure 13-13. COMPAQ Color Monitor

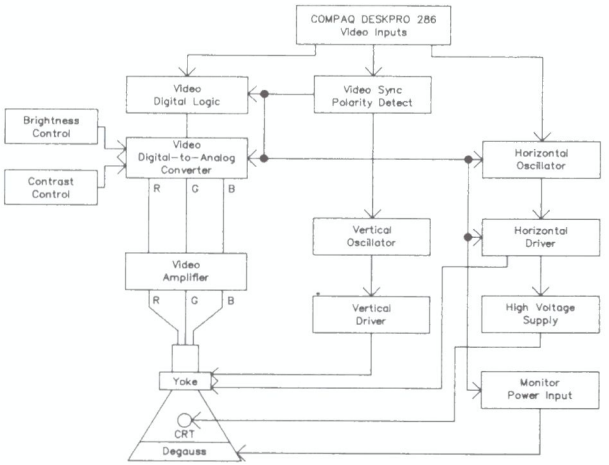


Figure 13-14. COMPAQ Color Monitor Functional Block Diagram

COMPAQ Color Monitor Specifications

Table 13-6 lists the COMPAQ Color Monitor specifications.

Table 13-6. COMPAQ Color Monitor Specifications

Monitor:	
Height	12 in. (30.4 cm)
Depth	15 in. (38.0 cm)
Width	13 in. (35.4 cm)
Weight	28 lb. (12.8 kg)
Display:	
640 pixels x 350 scan lines (64 colors)	
640 pixels x 200 scan lines (16 colors)	
13-in. screen (diagonal)	
90-degree deflection	
Signal Cable:	
Length	60 in. (1.5 m)
Interface	RGBI/RrGgBb using shielded 9-pin subminiature D-type connector
Power:	
Cable Length	60 in. (1.5 m)
Cable Connector	NEMA 5-15P (parallel blade plug, North American units only)
Voltage:	
North American units	120 VAC (60 Hz)
International units	220-240 VAC (50 to 60 Hz)
Power Consumption	100 w (maximum)
Environmental Requirements:	
Temperature:	
Operating	50°F to 104°F (10°C to 40°C)
Nonoperating	14°F to 131°F (-10°C to 55°C)
Humidity	10% to 95% (noncondensing)
Altitude	Mean sea level to 7000 ft. (2 100 m)

COMPAQ Color Monitor Installation Considerations

Adjustable Tilt Bar

The bottom of the monitor has a tilt bar that allows the monitor to be viewed in three positions: level and 5°- or 10°-angled views.

To adjust the tilt bar, gently set the monitor on its left side, push the spring-loaded tilt bar down and set it as desired. Then release the tilt bar and lock it into place.

Video Display Controller Compatibility

Connect the COMPAQ Color Monitor only to a video display controller board having standard RGBI or RrGgBb video outputs with a horizontal frequency output of 15.7 kHz or 21.8 kHz. The COMPAQ Color Monitor works with either the COMPAQ Enhanced Color Graphics Board or the COMPAQ Video Display Controller Board. When the monitor is connected to a video display controller board with incompatible video output signals, the display image, shape, and position may be distorted.

NOTE: The switch settings on the video display controller board may need to be changed before the COMPAQ Color Monitor functions correctly. (See your video display controller board operations guide for the correct switch settings for the COMPAQ Color Monitor.)

Connecting AC Power

For the North American units of the COMPAQ Color Monitor, the alternating-current (AC) power cable is an integral part of the monitor. To connect the monitor to AC power, plug the power cable into a standard 120-VAC (60-Hz) outlet.

For the International units of the COMPAQ Color Monitor, the AC power cable is a separate cable that must be plugged in to both the monitor and the AC outlet. Connect the "monitor end" of the power cable to the connector on the back of the monitor. Plug the "AC end" of the power cable into the AC outlet. International units operate on 220- to 240-VAC, 50- to 60-Hz power.

Controls

Figure 13-15 shows the following COMPAQ Color Monitor controls:

- Power ON/OFF Switch. The Power ON/OFF Switch turns on and off the monitor's AC power. Push the top of the "rocker-type" switch to turn on the monitor. Push the bottom of the switch to turn off the monitor.
- Contrast Control. The Contrast Control adjusts the difference in the degree of brightness among the colors. To increase the contrast, rotate the Contrast Control downward. To decrease the contrast, rotate the Contrast Control upward. The contrast control is not operative in 350 scan-line modes.
- Brightness Control. The Brightness Control adjusts the brightness of the display. To increase the brightness, rotate the Brightness Control downward. To decrease the brightness, rotate the Brightness Control upward.
- Vertical-Height, High-Frequency Mode Control (V-Height-H). The V-Height-H Control adjusts the screen size for the 350 scan-line modes. Adjust this control when you are in any of the 350 scan-line modes until the display height is suitable.
- Vertical-Height, Low-Frequency Mode Control (V-Height-L). The V-Height-L Control adjusts the screen size for the 200 scan-line modes. Adjust this control when you are in any of the 200 scan-line modes until the display height is suitable.

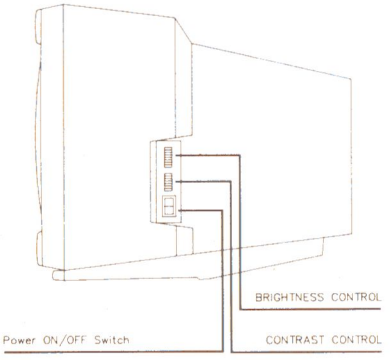
WARNING

Do Not Attempt To Adjust Any Internal Controls:

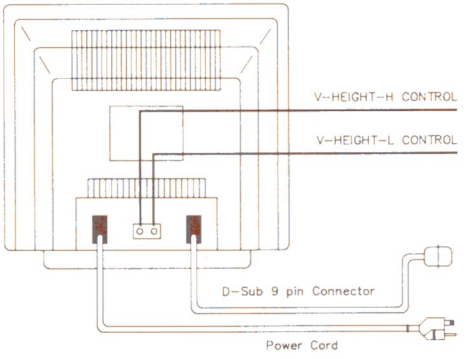
1. **Removing the cover of the monitor exposes you to dangerous voltages.**

2. **Improper adjustment of the internal controls can permanently damage the monitor.**

3. **Attempting to adjust the controls voids the warranty on the monitor.**



Right-Side View



Rear View

Figure 13-15. COMPAQ Color Monitor Controls

Self-Test

The COMPAQ Color Monitor has a self-test system. To perform this self-test:

1. Turn off the monitor.
2. Disconnect the monitor signal cable from the computer.
3. Turn on the monitor and look at the screen. The screen color will be white if the monitor is working properly after warm up.

If the screen is dark or any color other than white, contact your Authorized COMPAQ Computer Dealer for service.

COMPAQ Color Monitor Connectors

The COMPAQ Color Monitor has one signal connector, which is shown in Figure 13-16. The monitor interprets the video signal function according to the polarity of the vertical sync (VS) signal coming from the video display controller board. When the VS signal is active high (+ polarity), the monitor operates in the 200 scan-line mode. When the VS signal is active low (- polarity), the monitor operates in the 350 scan-line mode.

Table 13-7 lists the monitor connector signal descriptions. Figures 13-17 and 13-18 show the timing parameters for the COMPAQ Color Monitor.

Table 13-7. Monitor Connector Signal Descriptions

Pin	200 Scan-line Description	350 Scan-line Description
1	Signal Ground	Signal Ground
2	Not used	r-secondary red
3	R-red	R-primary red
4	G-green	G-primary green
5	B-blue	B-primary blue
6	I-intensity	g-secondary green
7	Not-used	b-secondary blue
8	HS-horizontal sync	HS-horizontal sync
9	VS-vertical sync	VS-vertical sync

Note: All signals are active-high TTL signals, except the VS signal. Polarity of VS determines the number of scan lines.

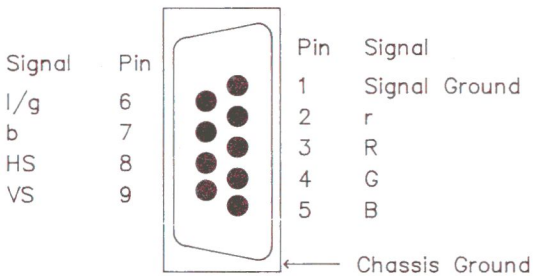
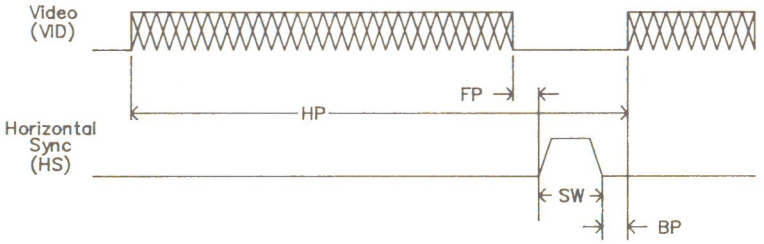
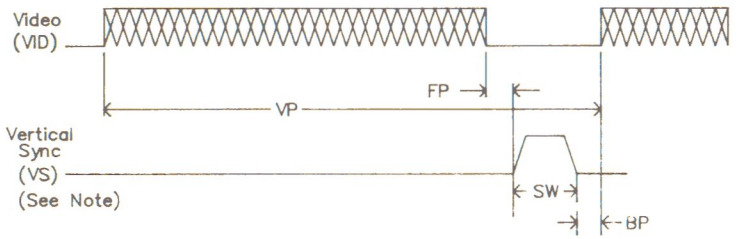


Figure 13-16. COMPAQ Color Monitor Signal Connector



Symbol	Parameter	350 Scan lines	200 Scan lines
HP	Horizontal Period	45.8 µs	63.7 µs
FP	Front Porch	0 µs	6.7 µs
SW	Sync Width	4.9 µs	4.5 µs
BP	Back Porch	1.5 µs	7.8 µs

Figure 13-17. COMPAQ Color Monitor Horizontal Timing



Symbol	Parameter	350 Scan lines	200 Scan lines
VP	Vertical Period	16.70 ms	16.80 ms
FP	Front Porch	0.00 ms	1.53 ms
SW	Sync Width	0.60 ms	0.19 ms
BP	Back Porch	0.08 ms	2.23 ms

Note: VS is active low for the 350 scan line mode.
VS is active high for the 200 scan line mode.

Figure 13-18. COMPAQ Color Monitor Vertical Timing

Chapter 14
BIOS PROGRAMMING GUIDE

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Chapter 14
BIOS PROGRAMMING GUIDE

14.1 INTRODUCTION

BIOS--basic input/output system--is a collection of programs that controls the most fundamental processes or functions of the system, such as:

- Executing power-on self-tests
- Initializing the system
- Interacting with video, diskette, and communications

The BIOS firmware is contained in a pair of ROM devices. The ROM devices are located on the COMPAQ PORTABLE 286® system board and on the Version 2 and Version 3 system board for the COMPAQ DESKPRO 286® . The ROMs are located on the system memory board for the COMPAQ DESKPRO 286 with the Version 1 system board. One ROM is provided for the even-numbered addresses, the second for the odd-numbered addresses. Each ROM is organized as 16 Kbytes and simultaneously appears in two address spaces: 0F8000h to 0FFFFFh (primary) and FF8000h to FFFFFFh (secondary). This double-mapping provides software compatibility with 8088/8086-based products.

Figure 14-1 shows a diagram of the ROM configurations.

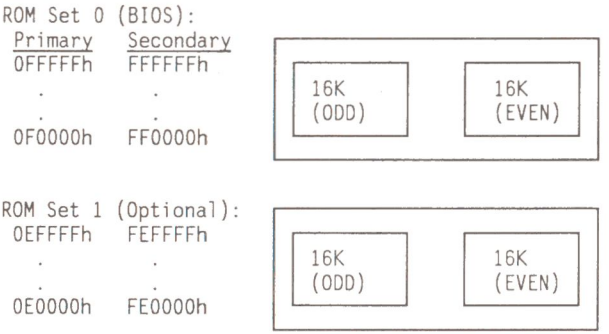


Figure 14-1. ROM Memory Addresses

Fundamentals of Interrupt Service Calls

Interactions with the system BIOS are at the machine-language level, meaning that the interacting program must be written using an assembler or other machine-language level program.

The 80286's interrupt (INT) instruction is used to access BIOS functions. This is a "software interrupt", or "service call", to request that a certain function be performed. For example, when the 80286 encounters the INT 10h (Video I/O) instruction, it invokes the program or routine in the BIOS memory that controls the video functions.

Before using the INT instruction, the 80286 registers must be set with the values appropriate to the function desired. The formats for the 80286 register values are described with each function. Likewise, the 80286 register values after the function call (INT) depend on the function. Interface routines to higher level language programs that use service calls must ensure that the register values are returned to the pre-service call state to prevent major software problems.

When the 80286 is operating in the Real mode, the system stores a software interrupt vector table in RAM memory, starting at address 0000:0000 (segment:offset). A vector is a pointer to another location. For example, when INT 10h is called, the 80286 looks to memory locations 40h..43h for the address of the video interrupt service routine; locations 40h..43h contain a vector to that service routine.

When operating in the Protected mode, the vector table can begin anywhere in physical memory as defined by the IDT (Interrupt Descriptor Table) base register in the 80286.

Interrupts caused by hardware devices also have service routines in memory. The vectors for these interrupts are included in the interrupt vectors memory locations table.

Some interrupt calls have more than one function available, requiring some method of specifying which function is desired. The AH register is loaded with the number of the desired function before the INT instruction.

In some cases, more than one parameter (value) must be loaded into the 80286 registers before the INT instruction. Ensure that all registers are properly set before using a software INT instruction.

The interrupt service calls return to the calling program with all register contents preserved, except for the AX register, and any other register specifically mentioned in the corresponding INT section.

BIOS Initialization

When the 80286 processor is reset, execution begins at address FFFFF0h, which is located in the system BIOS ROM. Processor reset can result from a power-on condition (cold start) or it can be initiated under program control, usually to resume program execution in the Real mode, discussed later.

The BIOS senses a power-on condition when the system flag (bit <2>) in the 8042 keyboard controller's status port is 0. Subsequent power-on functions performed by the BIOS consist of device initialization, diagnostic tests, configuration sensing and verification, and bootstrapping from either the diskette or fixed disk drives.

Normal Reset

Normal reset begins by initializing the programmable devices on the system board, turning off the diskette drive motors, and programming the video display controllers. After that, the first 128 Kbytes of RAM are tested. This is the minimum amount that must be operational for the system to proceed.

If this minimum amount is found to be faulty, a "XX000B YYZZ 201 - Memory Error" message is displayed. (See Appendix A for an explanation of the error messages.)

After the first 128 Kbytes of memory are successfully tested, a BIOS stack (SS:SP) is established and the BIOS RAM is initialized. Following this, devices on the system board are tested (and any errors reported on the active display), including the remaining base and extended memory. After all system memory is tested, the A20 gate is disabled, enabling 20-bit address wraparound compatible with 8088/8086-based hardware.

The Timer-Ticks-Since-Midnight counter in RAM at 0040:006C is initialized based on the time contained in the real-time clock (RTC). Next, the keyboard, diskette drive, and fixed disk drive, as well as their respective controllers, are initialized and tested. See Appendix A for a complete list of error codes.

At this point, any option BIOS ROMs used on expansion boards are scanned. If found, control is transferred to the ROM via a FAR CALL to the ROM segment at offset 0003h. After the option ROMs are scanned, a few housekeeping functions are performed including enabling NMI, checking the configuration memory for discrepancies, clearing the screen, setting the Reset Word at 0040:0072 to 0000h, and beeping the speaker according to the current processor speed:

```
8-MHz system -  one beep for the 6-MHz clock
                two beeps for the 8-MHz clock
12-MHz system - one beep for the 8-MHz clock
                two beeps for the 12-MHz clock.
```

Before bootstrapping the system, hardware interrupts IRQ1 (for the keyboard) and IRQ9 are also enabled. Control then transfers to INT 19h, the system bootstrap.

Software Reset

Because the processor can be reset for a variety of software-related reasons, a byte in the Configuration Memory (0Fh) has been set aside to record a "reset code". This code is loaded immediately before requesting the 8042 to issue a System Reset and is examined afterwards to tell the BIOS what operation was in effect before the reset. Additionally, when a vector is needed for a return address or pointer to a saved environment, the reset vector at address 0040:0067 is used.

Several reset codes have been set aside for use when system software needs to switch from Protected mode to the Real mode. The reset codes are listed in Table 14-1.

Table 14-1. Reset Codes

Code	Function	Reset Vector(0040:0067)
00h	Normal Reset	Not used
04h	Reset with Boot Request	Not used
05h	Initialize 8259 Interrupt Controllers	Return address (CS:IP)
09h	Return from Block Move	Pointer to stack frame (SS:SP) (used internally by BIOS INT 15h, AH = 87h)
0Ah	Do not initialize 8259 Interrupt Controllers	Return address (CS:IP)

Other reset codes are reserved by the BIOS and should not be used. On return to the destination environment, the SS and SP registers point to an area in BIOS RAM for all reset codes except for code 09h (Return from Block Move). This function uses the reset vector at 0040:0067 as a save area for SS:SP, a stack-frame pointer. The stack frame stores the 80286 registers in the following order, beginning at offset +00h (top of stack): DS, ES, DI, SI, BP, SP, BX, DX, CX, AX, IP, CS, and flags.

Programming Considerations

When developing software products or development tools, following a few generally accepted programming guidelines ensures the upward migration to higher performance systems. These guidelines are as follows:

1. Certain registers are unique or reserved to a specific microprocessor in the Intel family. Follow the Intel recommendations for the use of these registers and data structures. Typically, indiscriminate use of unique or reserved areas in the microprocessor prevents compatibility with other microprocessors in the Intel family. For example, relying on the value pushed on the stack by the PUSH SP instruction on 8088- or 8086-based systems prevents a software product from running on 80286-based systems. Use of the reserved areas on the 80286 segment registers may also cause compatibility problems. (See Intel documentation for additional software compatibility recommendations.)

2. Avoid any use, implicit or explicit, of the values of flags or registers that are declared undefined in the Intel documentation. The value contained by undefined flags or registers varies from one microprocessor to another under similar conditions. For example, the MUL (multiply) instruction, as described in the Intel 80286 Programmer's Reference Manual, indicates that the zero flag is undefined upon completion of an unsigned multiply operation. Relying on the value of the zero flag after a multiply operation can prevent a package from executing correctly across the Intel family of microprocessors.

3. When using with I/O devices in high-performance products, be aware that the minimum time between consecutive I/O accesses as specified by the I/O device may be exceeded. This circumstance results from the increased execution speed of I/O operations in high-performance 80286-based products. It typically occurs when performing consecutive I/O read or write operations to the same I/O device. Use JMP $+2 to add delay between I/O accesses for devices with minimum time between accesses of less than 1 us. Typical I/O devices in this category include the Intel DMA controller (8237), the Intel interrupt controller (8259A), and the Intel programmable interval timers (8245). For slower I/O devices, such as the keyboard and diskette controllers, use the READY/BUSY protocols provided by those controllers.

   It is important to avoid using NOP (No Operation instructions) as a delay between consecutive I/O operations to a device. JMP $+2 is much more effective, because it discards the contents of the prefetch queue. A typical JMP $+2 adds approximately a 1- to 2-us delay. A typical NOP adds approximately a 190- to 250-ns delay.

4. Avoid developing software that is dependent on the speed of program execution for timing operations. A large variation of execution speeds exists between 8088-, 8086-, and 80286-based products. This variation is likely to prevent software dependency on program execution speed from functioning properly on some systems. The system timer (Intel 8245 at I/O address 40h, Timer 0) provides a clock frequency that is common among all industry-standard personal computer products. This timer, with its readable time registers and interrupt capability, should be used for software timing functions. Using the timer ensures that the timing source remains constant among all compatible personal computer products.

The system timer is driven by a 1.19318-MHz clock and is programmed to generate interrupts at a frequency of 18.20687 Hz (approximately every 54.92 ms). When performing timing functions in the hundreds of milliseconds, use the system timer interrupt. For timing functions in the microsecond range, the values of the system timer counter registers can provide a time resolution of 838 ns per counter tick. (Note that the system counter registers decrement by 2.) A reading of the counter registers allows a calculation of the elapsed number of timer ticks, thus deriving the elapsed time between the events.

For example, for a delay of approximately 10 us, the system timer counter value can be read until 12 timer ticks have elapsed (a counter value difference of 24). Twelve system timer ticks correspond to approximately 10.05 us (12 ticks x 0.383 us/tick = 10.05 us).

Power-On System Initialization

The 80286 CPU is reset when power is turned on. The system can also be restarted by simultaneously pressing the CTRL, ALT, and DEL keys. On reset, the system begins execution starting at the reset address FFFFF0h. This address corresponds to the entry point of the power-on system initialization code in the system ROM.

The system initialization begins immediately on entry to the system ROM via the power-on reset vector at address FFFF0h. The initialization is responsible for performing the power-on self-tests, initializing all the standard I/O components in the system, testing RAM, and initializing the BIOS variables in RAM. The primary difference in the system initialization procedure between a power-on reset and a system restart (CTRL+ALT+DEL) is that the RAM is tested only during the power-on test initialization sequence. Also, during the system restart, the currently defined system speed is retained.

The system initialization procedure begins with the initialization of all programmable I/O devices in the system. These devices include the:

- Interrupt controllers (Intel 8259)
- DMA controllers (Intel 8237)
- Keyboard controller (Intel 8042)
- Video display controller
- Interval timer (Intel 8254)
- Floppy diskette controller
- Asynchronous communications port controller
- Parallel printer adapter
- Fixed disk controller

The initialization of the memory subsystem begins with a test of the ROM and RAM areas to detect any malfunctioning memory devices. The ROMs are tested via a checksum method. The ROM test must be successful for the power-on initialization sequence to continue. If a ROM checksum error occurs, the power-on initialization stops and a "101-ROM error" message is displayed.

The RAM test ensures that the first 128 Kbytes of base memory are fully operational. These first 128 Kbytes are essential to the remaining power-on initialization sequence for use as stack and for storage of variables. Once proper operation of this RAM area has been verified, the initialization procedure continues by testing the remainder of the base and extended RAM in the system.

14.2 BIOS INTERRUPTS SUMMARY

This section summarizes the interrupt calls used for each system function and the memory locations used by the BIOS for those functions.

The interrupts are categorized by function and are described in the following order:

- Processor
- Coprocessor
- Tick Counter/Real-Time Clock
- System
- Diskette
- Printer
- Asynchronous
- Keyboard
- Fixed Disk
- Video
- Miscellaneous

Interrupts are grouped into four categories: software (SW), CPU, hardware (HW), or pointer (PTR).

SW interrupts are explicitly issued by applications programs or system software. Interrupt service routines are provided by the BIOS ROM or other user-supplied system software. Interrupts form a standardized interface between applications programs, system software, and BIOS firmware.

CPU interrupts are initiated by the 80286 or 80287 as a result of a processing exception. For example, executing an invalid opcode causes an INT 06h.

HW interrupts are initiated by device signals on the 80286's Non-Maskable Interrupt (NMI) or Interrupt (INTR) pins. Signals on the INTR pin are arbitrated by the 8259A interrupt controllers. An interrupt-acknowledge cycle by the 80286 requests the active 8259A interrupt controller to place the actual interrupt number on the bus.

PTR interrupts are not used to transfer program control. They are 4-byte pointers in low memory, named for the interrupt-vector location they occupy. These pointers typically point to video, diskette, or fixed disk controller parameters, character dot-pattern tables, or tables of other pointers.

Table 14-2 summarizes the BIOS interrupts.

Table 14-2. BIOS Interrupts Summary

INT	Type	Function
00h	CPU	Zero Divide
01h	CPU	Single Step
02h	HW	Non-Maskable Interrupt (NMI)
03h	CPU	Software Breakpoint
04h	CPU	Arithmetic Overflow
05h	SW	Print Screen
05h	CPU	Bound Exceeded
06h	CPU	Invalid Opcode
07h	CPU	80287 Not Available
08h	CPU	Double Exception Error
08h	HW	IRQ0, Tick Counter
09h	CPU	80287 Segment Overrun
09h	HW	IRQ1, Keyboard
0Ah	CPU	Invalid TSS
0Ah	HW	Simulated IRQ2
0Bh	CPU	Segment Not Present
0Bh	HW	IRQ3, Comm, Secondary
0Ch	CPU	Stack Segment Overflow
0Ch	HW	IRQ4, Comm, Primary
0Dh	CPU	General Protection
0Dh	HW	IRQ5
0Eh	HW	IRQ6, Diskette
0Fh	HW	IRQ7, Printer
10h	SW	Video I/O
11h	SW	Configuration
12h	SW	Base Memory Size
13h	SW	Diskette Drive I/O
13h	SW	Fixed Disk Drive I/O
14h	SW	Communications I/O
15h	SW	BIOS Extension
16h	SW	Keyboard I/O
17h	SW	Printer I/O
18h	SW	Boot Fail
19h	SW	Bootstrap
1Ah	SW	Tick Counter/RTC
1Bh	SW	Control-Break Service
1Ch	SW	Tick Counter Service
1Dh	PTR	Video Cont. Bd. Parameters
1Eh	PTR	Diskette Parameter Table
1Fh	PTR	Ext Graphics Char Set
40h	SW	Diskette Drive I/O
41h	PTR	Fixed Disk Drive 1 Parameters
46h	PTR	Fixed Disk Drive 2 Parameters
4Ah	SW	RTC Alarm Service
70h	HW	IRQ8, Real Time Clock (RTC)
71h	HW	IRQ9
72h	HW	IRQ10
73h	HW	IRQ11
74h	HW	IRQ12
75h	HW	IRQ13, 80287 Error
76h	HW	IRQ14, Fixed Disk Drive
77h	HW	IRQ15

In addition to using a section of RAM for the interrupt vector table (see Table 14-3), the system BIOS uses another section for status information and buffers for data transfers, and so on.

Table 14-3. Memory Locations for Interrupts

INT	Address	Bytes
00h	0000:0000	4
01h	0000:0004	4
02h	0000:0008	4
03h	0000:000C	4
04h	0000:0010	4
05h	0000:0014	4
06h	0000:0018	4
07h	0000:001C	4
08h	0000:0020	4
09h	0000:0024	4
0Ah	0000:0028	4
0Bh	0000:002C	4
0Ch	0000:0030	4
0Dh	0000:0034	4
0Eh	0000:0038	4
0Fh	0000:003C	4
10h	0000:0040	4
11h	0000:0044	4
12h	0000:0048	4
13h	0000:004C	4

(Continued)

Table 14-3. (Continued)

INT	Address	Bytes
14h	0000:0050	4
15h	0000:0054	4
16h	0000:0058	4
17h	0000:005C	4
18h	0000:0060	4
19h	0000:0064	4
1Ah	0000:0068	4
1Bh	0000:006C	4
1Ch	0000:0070	4
1Dh	0000:0074	4
1Eh	0000:0078	4
1Fh	0000:007C	4
40h	0000:0100	4
41h	0000:0104	4
46h	0000:0118	4
4Ah	0000:0128	4
70h	0000:01C0	4
71h	0000:01C4	4
72h	0000:01C8	4
73h	0000:01CC	4
74h	0000:01D0	4
75h	0000:01D4	4
76h	0000:01D8	4
77h	0000:01DC	4

Table 14-4 lists RAM locations used by the BIOS.

Table 14-4. RAM Locations Used by the BIOS

Address	Bytes	Function
0040:0000	2	Base Address of Comm Port 0 (COM1)
0040:0002	2	Base Address of Comm Port 1 (COM2)
0040:0004	2	Base Address of Comm Port 2
0040:0006	2	Base Address of Comm Port 3
0040:0008	2	Base Address of Printer Port 0 (LPT1)
0040:000A	2	Base Address of Printer Port 1 (LPT2)
0040:000C	2	Base Address of Printer Port 2 (LPT3)
0040:000E	2	Base Address of Printer Port 3
0040:0010	2	System Configuration
0040:0012	1	Used By Power-On Diagnostics
0040:0013	2	Base Memory Size (In Kbytes)
0040:0015	1	Previous Scan Code
0040:0016	1	Keyclick Loudness
0040:0017	2	Keyboard Bit Status
0040:0019	1	Accumulator for ALT Key Input
0040:001A	2	Keyboard Buffer Pointer - Head
0040:001C	2	Keyboard Buffer Pointer - Tail
0040:001E	32	Keyboard Type-Ahead Buffer - 16 Entries
0040:003E	1	Diskette Drive Status
0040:003F	1	Motor Status
0040:0040	1	Motor Off Time-Out Counter
0040:0041	1	Diskette Last Operation Status
0040:0042	7	Diskette Drive Controller Status
0040:0049	1	Video Mode
0040:004A	2	Number of Columns on Screen
0040:004C	2	Length of Screen Memory Bytes
0040:004E	2	Starting Address for Screen Memory
0040:0050	16	Cursor Save Area for Each Page (8 Entries)
0040:0060	2	Cursor Mode (Start and End Scan Line)
0040:0062	1	Current Page
0040:0063	2	Base Address of Active Video Adapter Board
0040:0065	1	Current Mode
0040:0066	1	Current Color
0040:0067	4	Reset Vector
0040:006B	1	Interrupt Occurred Flag
0040:006C	4	Timer Ticks Since Midnight
0040:0070	1	Timer-Rolled-Over Flag
0040:0071	1	Break Bit
0040:0072	2	Reset Word
0040:0074	1	Fixed Disk Drive Status of Last Operation
0040:0075	1	Number of Fixed Disk Drives
0040:0076	1	Fixed Disk Drive Control Byte
0040:0077	1	Reserved

(Continued)

Table 14-4. (Continued)

Address	Bytes	Function
0040:0078	1	Time-Out for Printer Port 0 (LPT1)
0040:0079	1	Time-Out for Printer Port 1 (LPT2)
0040:007A	1	Time-Out for Printer Port 2 (LPT3)
0040:007B	1	Time-Out for Printer Port 3
0040:007C	1	Time-Out for Comm Port 0 (COM1)
0040:007D	1	Time-Out for Comm Port 1 (COM2)
0040:007E	1	Time-Out for Comm Port 2
0040:007F	1	Time-Out for Comm Port 3
0040:0080	2	Keyboard Buffer Begin
0040:0082	2	Keyboard Buffer End
0040:0084	7	Reserved
0040:008B	1	Last Data Rate Selected
0040:008C	1	Fixed Drive Status Registered, Last Operation
0040:008D	1	Fixed Drive Error Registered, Last Operation
0040:008E	1	Interrupt Occurred Flag
0040:008F	1	Fixed Disk Drive Controller Board Installed
0040:0090	1	Drive 1(A) Media State
0040:0091	1	Drive 2(B) Media State
0040:0092	1	Drive 1(A) Operation Start State
0040:0093	1	Drive 2(B) Operation Start State
0040:0094	1	Drive 1(A) Current Track
0040:0095	1	Drive 2(B) Current Track
0040:0096	1	Reserved

(Continued)

Table 14-4. (Continued)

Address	Bytes	Function
0040:0097	1	Keyboard LED Flags
0040:0098	4	Pointer to Caller's Wait Flag
0040:009C	4	Wait Count (32-Bit)
0040:00A0	1	Wait Active Flag
0040:00A1	95	Reserved
0040:0100	1	Print Screen Status

14.3 PROCESSOR INTERRUPTS

The 80286 processor has several predefined interrupts used for notifying system or applications software of execution exceptions. These are categorized as processing, debug, and arithmetic:

- Processing interrupts are:
  - INT 05h (Bound Exceeded)
  - INT 06h (Invalid Opcode)
  - INT 08h (Double Exception Detected)
  - INT 0Ah (Invalid TSS)
  - INT 0Bh (Segment Not Present)
  - INT 0Ch (Stack Segment Overrun)
  - INT 0Dh (General Protection)
- Debug interrupts are:
  - INT 01h (Single Step)
  - INT 03h (Software Breakpoint)
- Arithmetic interrupts are:
  - INT 00h (Divide By Zero)
  - INT 04h (Arithmetic Overflow)

(Refer to the Intel iAPX 286 Programmer's Reference Manual for a detailed explanation of each interrupt.)

Table 14-5 lists the BIOS processor interrupts. Table 14-6 lists the memory locations used.

Table 14-5. Processor Interrupts

INT	Type	Function
00h	CPU	Divide by Zero
01h	CPU	Single Step
03h	CPU	Software Breakpoint
04h	CPU	Arithmetic Overflow
05h	CPU	Bound Exceeded
06h	CPU	Invalid Opcode
08h	CPU	Double Exception Error
0Ah	CPU	Invalid TSS
0Bh	CPU	Segment Not Present
0Ch	CPU	Stack Segment Overrun
0Dh	CPU	General Protection

Table 14-6. Memory Locations Used by Processor Interrupts

Memory Location	Bytes	Function/Vector
0000:0000	4	INT 00h
0000:0004	4	INT 01h
0000:000C	4	INT 03h
0000:0010	4	INT 04h
0000:0014	4	INT 05h
0000:0018	4	INT 06h
0000:0020	4	INT 08h
0000:0028	4	INT 0Ah
0000:002C	4	INT 0Bh
0000:0030	4	INT 0Ch
0000:0034	4	INT 0Dh

INT 00h - CPU - DIVIDE BY ZERO

INT 00h is initiated when a Divide by Zero or Divide Overflow operation takes place in the 80286.

ROM ENTRY: Points to an interrupt return.

ROM ACTION: Control returns to the calling program.

INPUT: None.

OUTPUT: None.

INT 01h - CPU - SINGLE STEP

INT 01h is initiated when an instruction is executed with the trace flag (TF) set.

ROM ENTRY: Points to an interrupt return.

ROM ACTION: Control returns to the calling program.

INPUT: None.

OUTPUT: None.

USE: It is the responsibility of MS-DOS or the applications program (usually DEBUG or DDT) to set this vector for useful action.

INT 03h - CPU - SOFTWARE BREAKPOINT

INT 03h is initiated by execution of either the single-byte or double-byte INT 03h instruction (opcode CCh or CDh, 03h).

When the system encounters this interrupt, it jumps to the address pointed to by the INT 03h vector (0000:000C).

This interrupt provides a debugging program with a means of suspending program execution so that system control can return to the debug program.

ROM ENTRY: Points to an interrupt return.

ROM ACTION: Control returns to the calling program.

INPUT: None.

OUTPUT: None.

USE: It is the responsibility of MS-DOS or the applications program to set this vector for useful action.

INT 04h - CPU - ARITHMETIC OVERFLOW

INT 04h is initiated by execution of an INTO instruction when the overflow flag (OF) is set.

ROM ENTRY: Points to an interrupt return.

ROM ACTION: Control returns to the calling program.

INPUT: None.

OUTPUT: None.

USE: It is the responsibility of MS-DOS or the applications program to set the vector to process this interrupt.

INT 05h - CPU - BOUND EXCEEDED - SW - PRINT SCREEN

INT 05h is initiated either by explicitly executing an INT 05h (Print Screen) instruction or by exceeding the limits specified in the Bound Exceeded instruction.

ROM ENTRY: Bound Exceeded is not supported by BIOS (the interrupt vector points to the Print Screen handler).

ROM ACTION: See above.

INPUT: See above.

OUTPUT: See above.

USE: A replacement INT 05h handler can determine the source of the interrupt by examining the 2 bytes previous to the instruction pointed to by the return address on the stack. If the bytes are CDh, 05h, the source of the interrupt is an INT 05h. It is the responsibility of MS-DOS or the applications program to set the vector to process the INT 05h interrupt.

INT 06h - CPU - INVALID OPCODE

INT 06h is initiated by the 80286 when an illegal instruction is executed.

ROM ENTRY: Points to an interrupt return.

ROM ACTION: None.

INPUT: None.

OUTPUT: None.

INT 08h - CPU - DOUBLE-EXCEPTION ERROR - HW - IRQ0, TICK COUNTER

INT 08h normally handles the tick-counter hardware interrupts from IRQ0. However, when the system is operating in the Protected mode, the 80286 issues INT 08h when a Double-Exception Error (processor cannot continue) is detected.

The operating system software running in the Protected mode can readily relocate hardware interrupts IRQ0 through IRQ7 to another block of eight interrupt vectors to avoid conflict. (See INT 15h, AH = 89h.)

INPUT: None.

OUTPUT: None.

INT 0Ah - CPU - INVALID TASK-STATE SEGMENT (TSS) - HW - SIMULATED IRQ2

INT 0Ah is normally issued by the BIOS in response to processing an INT 70h. However, when the system is operating in the Protected mode, the 80286 issues an INT 0Ah when an Invalid Task-State Segment (TSS) is encountered.

INPUT: None.

OUTPUT: None.

INT 0Bh - CPU - SEGMENT NOT PRESENT - HW - IRQ3, COMM, SECONDARY

In the Protected mode, the 80286 issues INT 0Bh when it detects a reference to a segment not currently mapped by its memory-management hardware. Otherwise, the default initialization of the interrupt controllers directs interrupts from IRQ3 through INT 0Bh.

INT 0Bh is not processed by the BIOS other than to return control to the calling program.

INPUT: None.

OUTPUT: None.

INT 0Ch - CPU - STACK SEGMENT OVERFLOW - HW - IRQ4, COMM, PRIMARY

In the Protected Virtual- Memory mode, the 80286 issues INT 0Ch when it detects a push onto a stack that exceeds the space as allocated by memory management. Otherwise, the default initialization of the interrupt controllers directs interrupts from IRQ4 through INT 0Ch.

INT 0Ch is not processed by the BIOS other than to return control to the calling program.

INPUT: None.

OUTPUT: None.

INT 0Dh - CPU - GENERAL PROTECTION - HW - IRQ5, NOT USED

INT 0Dh normally handles the interrupts from IRQ5, which is not used. However, in the Protected mode, the 80286 issues an INT 0Dh when a General Protection exception is detected.

Operating system software running in the Protected mode can readily relocate hardware interrupts IRQ0 through IRQ7 to another block of eight interrupt vectors to avoid conflict with CPU-type INT 0Dh. (See INT 15h, AH = 89h.)

INPUT: None.

OUTPUT: None.

14.4 COPROCESSOR INTERRUPTS

The BIOS provides two basic areas of support for the 80287 coprocessor:

1. BIOS checks for the presence of the 80287 during the system initialization process. When the 80287 is present, BIOS sets the appropriate bits in the machine status word in the 80286 processor.

2. The BIOS transfers INT 75h (IRQ13, 80287 Error) to INT 02h for compatibility with software written for 8088/8086-based products.

After initialization, coprocessor interrupts INT 07h (80287 Not Present) and INT 09h (80287 Segment Overrun) are normally supported by systems software (MS-DOS) and are not handled by the BIOS.

Table 14-7 lists the BIOS coprocessor interrupts. Table 14-8 lists the memory locations used by coprocessor interrupts.

Table 14-7. Coprocessor Interrupts

INT	Type	Function
07h	CPU	80287 Not Present
09h	CPU	80287 Segment Overrun
75h	HW	IRQ13, 80287 Error

Table 14-8. Memory Locations Used by Coprocessor Interrupts

Memory Location	Bytes	Function/Vector
0000:001C	4	INT 07h
0000:0024	4	INT 09h
0000:01D4	4	INT 75h

INT 07h - CPU - 80287 NOT PRESENT

INT 07h is initiated by the 80286 when the execution of an 80287 instruction is attempted with the EM bit of the machine status word set (80287 coprocessor not present).

ROM ENTRY: Points to an interrupt return.

ROM ACTION: None.

INPUT: None.

OUTPUT: None.

INT 09h - CPU - 80287 SEGMENT OVERRUN - HW - IRQ1, KEYBOARD

INT 09h normally handles the keyboard hardware interrupts from IRQ1. However, when the system is operating in the Protected mode, the 80286 issues INT 09h when it detects an 80287 Segment Overrun exception.

Operating system software running in the Protected mode can readily relocate hardware interrupts IRQ0 through IRQ7 to another block of eight interrupt vectors to avoid conflict. (See INT 15h, AH = 89h.)

INPUT: None.

OUTPUT: None.

INT 75h - HW - IRQ13, 80287 ERROR

INT 75h occurs when an unmasked error condition exists on the 80287 coprocessor. This error can be caused by arithmetic overflow or underflow, division-by-zero operations, and the loading of invalid numbers.

ROM ENTRY: Points to INT 75h handler.

ROM ACTION: BIOS performs an EOI (End of Interrupt) sequence on Interrupt Controller 1 (master), outputs a 00h to port F0h to clear the 80287 BUSY signal, and then invokes the INT 02h (Non-Maskable Interrupt) handler to provide compatibility with 8088/8086-based software.

USE: This vector can be changed by system software or an applications program to point to a user-supplied routine that notifies applications software of floating-point number computation exceptions.

INPUT: None.

OUTPUT: None.

14.5 TICK COUNTER/REAL-TIME CLOCK (RTC) INTERRUPTS

The tick counter/RTC interrupts provide all timekeeping functions in the BIOS. The tick counter/RTC interrupts are actually two separate services attached to two different hardware elements.

The tick counter is one counter of the 8254 programmable interval timer. The tick counter is provided mainly for compatibility with software written for 8088/8086-based products. The real-time clock (RTC) is part of the MC146818 RTC and Configuration Memory Device. The RTC provides battery-backed-up time-of-day information and alarm service in a binary-coded-decimal (BCD) format.

During power-on, the BIOS uses the RTC to initialize the tick counter. Thereafter, the tick counter maintains a 32-bit counter in the BIOS RAM area that contains the number of ticks since midnight. Ticks arrive from hardware interrupt IRQ0 and are vectored through INT 08h at a rate of approximately 18.2 ticks per second (18.2 Hz). When the counter reaches 1573040 (24 hours), it rolls over to zero and sets a rolled-over flag in BIOS RAM.

In addition to timekeeping, the tick counter also decrements a countdown timer variable in BIOS RAM and, on reaching zero, turns off the diskette drive motors. A periodic interrupt to applications software is provided by the BIOS calling INT 1Ch every tick. The vector in INT 1Ch is initialized at power-on to point to a dummy interrupt return.

RTC BIOS support provides an interface to the real-time-clock portion of the MC146818 Calendar Clock/Configuration Memory device. This device maintains the time-of-day and an alarm function in hardware. If enabled, it also interrupts the processor on IRQ8 vectored through INT 70h at a rate of 1024 interrupts per second (one every 976 us).

Three software services are driven by the RTC hardware interrupt to INT 08h: Event Wait (INT 15h, AH = 83h), Unconditional Wait (INT 15h, AH = 86h), and RTC Alarm Service (INT 4Ah). (See their respective descriptions for further information.)

Table 14-9 lists the BIOS tick counter/real-time-clock (RTC) interrupts. Table 14-10 lists the memory locations used.

Table 14-9. Tick Counter/Real-Time-Clock (RTC) Interrupts

INT	Type	Function
1Ah	SW	Tick Counter/RTC
1Ch	SW	Tick Counter Service
4Ah	SW	RTC Alarm Service
08h	HW	IRQ0, Tick Counter
70h	HW	IRQ8, RTC Interrupt

Table 14-10. Memory Locations Used by Tick Counter/ Real-Time-Clock (RTC) Interrupts

Memory Location	Bytes	Function
0000:0020	4	INT 08h Vector
0000:0068	4	INT 1Ah Vector
0000:0070	4	INT 1Ch Vector
0000:0128	4	INT 4Ah Vector
0000:01C0	4	INT 70h Vector
0040:006B	1	Interrupt Occurred Flag
0040:006C	4	Timer Ticks Since Midnight
0040:0070	1	Timer Rolled-Over Flag
0040:0098	4	Pointer to Caller's Wait Flag
0040:009C	4	Wait Count (32 bit)
0040:00A0	1	Wait Active Flag

INT 1Ah - SW - TICK COUNTER/RTC

INT 1Ah reads or sets the tick counter, RTC time, RTC date, or RTC alarm. The tick counter is a 32-bit location in BIOS RAM that is incremented 18.2 times per second, that is, once for each INT 08h hardware interrupt. When a count of 1,573,040 (001800B0h) is reached (24 hours), the BIOS resets the tick counter to 0, and sets the rolled-over flag in location 0040:0070 to a 1. System software normally initializes this counter to the time of day represented as ticks since midnight.

RTC functions handle I/O to the MC146818 Real-Time Clock and Configuration Memory Device and maintains in BIOS RAM a 32-bit event wait counter. The RTC operates independently of the tick counter.

ROM ENTRY: Points to tick counter/RTC ROM entry point.

ROM ACTION: Upon entry, control is transferred to one of eight routines based on the function code in register AH. Illegal function codes cause control to simply return to the calling program. All registers are preserved except those returning a value.

Table 14-11 lists a summary of functions for this interrupt.

Table 14-11. Function Summary

AH	Function
00h	Read Tick Counter
01h	Set Tick Counter
02h	Read RTC Time
03h	Set RTC Time
04h	Read RTC Date
05h	Set RTC Date
06h	Set RTC Alarm
07h	Reset RTC Alarm

Interrupts remain enabled.

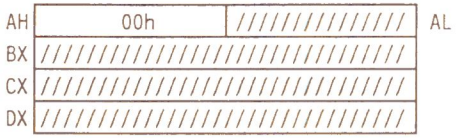
The only tick counter/RTC function (INT 1Ah) that affects the callers flags is the Set RTC Alarm function. The carry flag (CF) is set to 1 when the alarm is already set (alarm already active).

These functions and their related parameters are described in detail on the following pages.

INT 1Ah, AH = 00h - READ TICK COUNTER

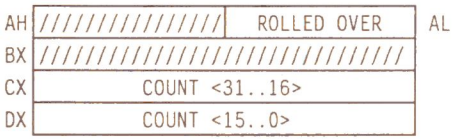
INT 1Ah, AH = 00h reads the contents of the tick counter and places these values in the output registers.

INPUT: AH = 00h



OUTPUT:
AL = Rolled-Over Flag
= 1 when 24 hours have elapsed since last read

CX = High portion of count
DX = Low portion of count



The rolled-over flag is cleared by this interrupt.

The tick counter increments continuously:
18.2 times per second, 1092 times per minute,
65543 times per hour, or 1,573,040 times per day.

INT 1Ah, AH = 01h - SET TICK COUNTER

INT 1Ah, AH = 01h loads the tick counter with the specified values.

INPUT:
AH = 01h
CX = High portion of count
DX = Low portion of count

AH	01h	////////////////	AL
BX	////////////////////////////////		
CX	COUNT <31..16>		
DX	COUNT <15..0>		

OUTPUT: None.

The rolled-over flag is cleared by this interrupt.

INT 1Ah, AH = 02h - READ RTC TIME

INT 1Ah, AH = 02h reads the RTC time and places the value in the output registers.

INPUT: AH = 02h

AH	02h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUT:
CH = BCD Hours
CL = BCD Minutes
DH = BCD Seconds

AX	////////////////////////////////		
BX	////////////////////////////////		
CH	BCD HOURS	BCD MINUTES	CL
DH	BCD SECONDS	////////////////	DL

INT 1Ah, AH = 03h - SET RTC TIME

INT 1Ah, AH = 03h loads the specified values into the RTC time register.

INPUT:
AH = 03h
CH = BCD Hours
CL = BCD Minutes
DH = BCD Seconds
DL = 00h if Standard Time (ST)
= 01h if Daylight Savings Time (DST)

AH	03h	////////////////	AL
BX	////////////////////////////////		
CH	BCD HOURS	BCD MINUTES	CL
DH	BCD SECONDS	ST/ST	DL

OUTPUT: None.

INT 1Ah, AH = 04h - READ RTC DATE

INT 1Ah, AH = 04h reads the date values from the RTC registers and stores these values in the output registers.

INPUT: AH = 04h

AH	04h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUT:
CH = BCD Century (19 or 20)
CL = BCD Year
DH = BCD Month
DL = BCD Date

AX	////////////////////////////////		
BX	////////////////////////////////		
CH	BCD CENTURY	BCD YEAR	CL
DH	BCD MONTH	BCD DATE	DL

INT 1Ah, AH = 05h - SET RTC DATE

INT 1Ah, AH = 05h loads the date into the RTC date register.

INPUT:
AH = 05h
CH = BCD Century (19 or 20)
CL = BCD Year
DH = BCD Month
DL = BCD Date

AH	05h	////////////////	AL
BX	////////////////////////////////		
CH	BCD CENTURY	BCD YEAR	CL
DH	BCD MONTH	BCD DATE	DL

OUTPUT: None

INT 1Ah, AH = 06h - SET RTC ALARM

INT 1Ah, AH = 06h loads the specified values into the RTC alarm register.

INPUT:
AH = 06h
CH = BCD Hours
CL = BCD Minutes
DH = BCD Seconds

AH	06h	////////////////	AL
BX	////////////////////////////////		
CH	BCD HOURS	BCD MINUTES	CL
DH	BCD SECONDS	////////////////	DL

OUTPUT:
Flags unaffected when no previous alarm is pending.
CF = 1, IF = 1 when an alarm is already pending.

The RTC interrupt (IRQ8) is enabled on Interrupt Controller 2 by the Set RTC Alarm function, but is not disabled by the Reset RTC Alarm function call.

INT 1Ah, AH = 07h - RESET RTC ALARM

INT 1Ah, AH = 07h resets the RTC Alarm register.

INPUT: AH = 07h

AH	07h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUT: None.

INT 1Ch - SW - TICK COUNTER SERVICE

INT 1Ch is called from the ROM at every interval-timer clock tick to provide the user with a means of executing code on a periodic basis (18.2 times per second).

ROM ENTRY: Points to a dummy interrupt return.

ROM ACTION: Returns control to the calling program.

INPUT: None.

OUTPUT: None.

USE: The vector for this interrupt can be changed to point to a user-supplied routine to be called at each hardware timer clock tick. The user routine must save all registers used and return with IRET.

INT 4Ah - SW - RTC ALARM SERVICE

INT 4Ah interrupt is called from the ROM when the alarm function of the RTC has been enabled and the desired time reached. INT 4Ah is provided to notify user programs when a specified time of day is reached.

ROM ENTRY: Points to a dummy interrupt return.

ROM ACTION: Returns control to the calling program.

USE: The vector for this interrupt can be changed by system software or an applications program to point to a user-supplied routine.

INT 08h - HW - IRQ0 TICK COUNTER INTERRUPT - CPU - DOUBLE-EXCEPTION ERROR

INT 08h can be reached in one of two ways. INT 08h normally handles the tick counter hardware interrupts from IRQ0. However, in the Protected mode, the 80286 issues INT 08h when it detects a Double-Exception Error (processor cannot continue).

Operating system software running in the Protected mode can readily relocate hardware interrupts IRQ0 through IRQ7 to another block of eight interrupt vectors to avoid conflict. (See INT 15h, AH = 89h.)

INT 08h is hardware-initiated by the output of Interval Timer Counter 0 at a rate of 18.2 times per second (18.2 Hz). INT 08h provides timekeeping functions, turns off the diskette drive motors, and makes calls to INT 1Ch.

ROM ENTRY: Points to ROM tick-counter interrupt handler.

ROM ACTION: ROM code increments the contents of a 32-bit double-word. When the count reaches 1573040 (001800B0h), a flag is set (= 1) indicating that the timer has rolled past a day since last read and that the 32-bit double word is cleared to 0 for the next day's incrementing.

INPUT: Double-word counter.

OUTPUT: Double-word counter, incremented rolled-over flag.

USE: The contents of the counter can be set or read by calls to INT 1Ah and can be used to keep track of elapsed time (since midnight). A user-supplied routine may also be periodically invoked from INT 1Ch. (See INT 1Ah and INT 1Ch for details.)

The vector for this interrupt is normally not changed by the user.

INT 70h - HW - IRQ8, RTC INTERRUPT

The RTC device (when enabled) interrupts the processor approximately every 976 us, which is the period of the RTC clock.

ROM ENTRY: Points to RTC interrupt handler.

ROM ACTION: The interrupt handler performs an EOI to the Interrupt Controller 2 (slave), then does an EOI to the Interrupt Controller 1 (master). The handler recognizes alarm interrupts and periodic interrupts. The periodic interrupt is used to implement the Wait and Event Wait (unconditional) INT 15h functions.

When a periodic interrupt occurs, a check is made to ensure that a Wait or Wait Event is defined. If so, the 32-bit counter in RAM locations 0040:009C and 0040:009E is decremented and checked for completion. If the timeout has expired, then the Periodic Interrupt Enable is disabled, the wait active flag in RAM at 0040:00A0 is cleared, signaling the user's semaphore. This semaphore is bit <7> of a byte pointed to by location 0040:0098.

When a Timer Alarm Interrupt occurs, a call to INT 4Ah is performed. The caller is expected to intercept INT 4Ah before calling the Set Alarm function.

INPUT: None

OUTPUT: Event Wait Timer decremented.

USE: Used by BIOS to implement the event timer and alarm functions.

14.6 SYSTEM INTERRUPTS

This section contains descriptions of general BIOS services that are not attached to specific I/O devices. These include INT 11h and INT 12h for system configuration information; INT 15h for BIOS extensions, such as multitasking support; INT 18h and INT 19h for bootstrap operations; and INT 02h for memory parity errors.

Table 14-12 lists the BIOS System Interrupts. Table 14-13 lists the memory locations used.

Table 14-12. System Interrupts

INT	Type	Function
11h	SW	Equipment Configuration
12h	SW	Base Memory Size
15h	SW	BIOS Extension
18h	SW	Boot Fail
19h	SW	Bootstrap
02h	HW	Non-Maskable Interrupt (NMI)

Table 14-13. Memory Locations Used by System Interrupts

Memory Location	Bytes	Function/Vector
0000:0008	4	INT 02h
0000:0044	4	INT 11h
0000:0048	4	INT 12h
0000:0054	4	INT 15h
0000:0060	4	INT 18h
0000:0064	4	INT 19h
0040:0010	2	System Configuration
0040:0013	2	Base Memory Size (in Kbytes)
0040:0067	4	Reset Vector
0040:0072	2	Reset Word
0040:0098	4	Pointer to Caller's Wait Flag
0040:009C	4	Wait Count (32-bit)
0040:00A0	1	Wait Active Flag

INT 11h - SW - EQUIPMENT CONFIGURATION

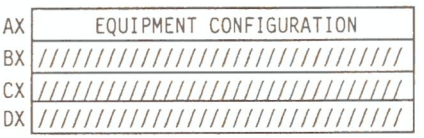
INT 11h returns a bit-encoded word relating the number and type of hardware devices installed.

ROM ENTRY: Points to Equipment Configuration ROM entry point.

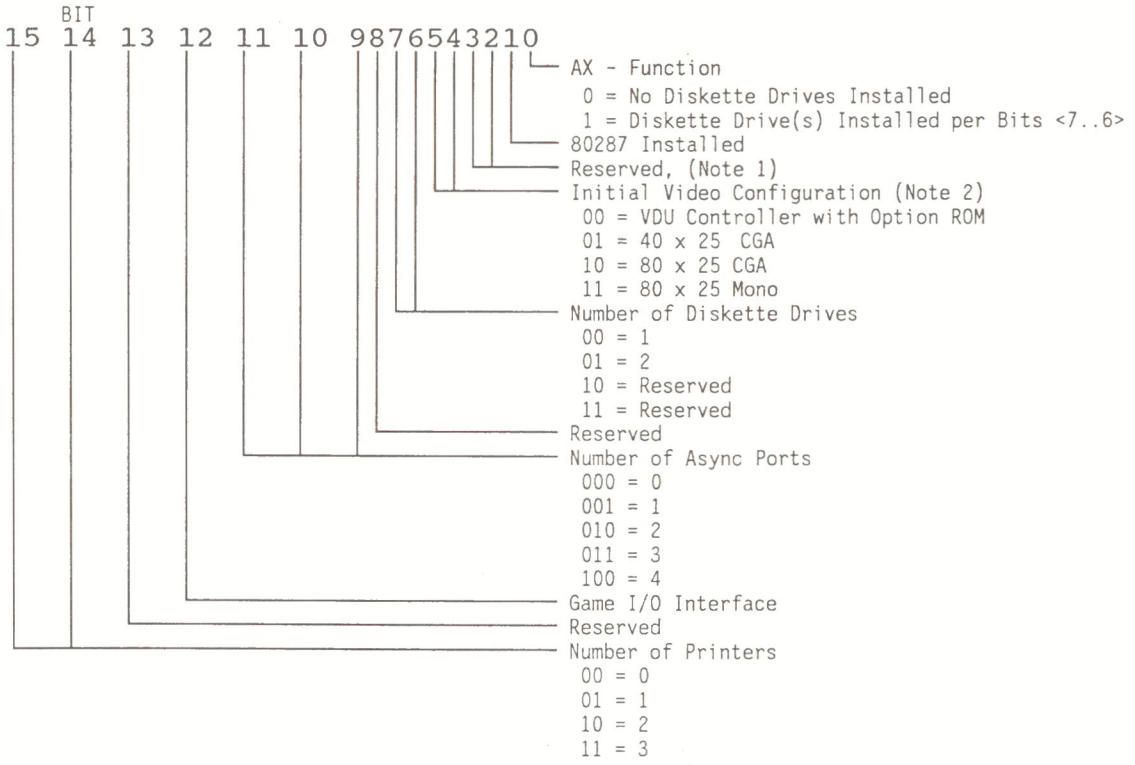
ROM ACTION: The equipment status word is initialized on power-on. Calls by INT 11h return the contents of this word in register AX.

INPUT: None.

OUTPUT: AX = Configuration



The following bit map shows the bit values for the Equipment Configuration Word:


BIT
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
AX - Function
0 = No Diskette Drives Installed
1 = Diskette Drive(s) Installed per Bits <7..6>
80287 Installed
Reserved, (Note 1)
Initial Video Configuration (Note 2)
00 = VDU Controller with Option ROM
01 = 40 x 25 CGA
10 = 80 x 25 CGA
11 = 80 x 25 Mono
Number of Diskette Drives
00 = 1
01 = 2
10 = Reserved
11 = Reserved
Reserved
Number of Async Ports
000 = 0
001 = 1
010 = 2
011 = 3
100 = 4
Game I/O Interface
Reserved
Number of Printers
00 = 0
01 = 1
10 = 2
11 = 3

Notes: 1. Reserved bits should be masked out of any processing.
2. Bits <5..4> normally indicate Ports an initial video configuration of 80 x 25 text.

INT 12h - SW - BASE MEMORY SIZE

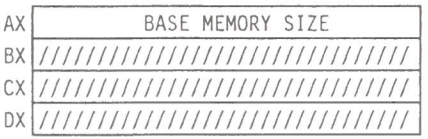
INT 12h returns to the caller the amount of base RAM installed in 1-Kbyte increments.

ROM ENTRY: Points to Base Memory Size ROM entry point.

ROM ACTION: The base memory size word is initialized at power-on. Calls by INT 12h place the number of contiguous 1-Kbyte blocks of base memory in register AX.

INPUT: None.

OUTPUT: AX = Contiguous base memory size in 1-Kbyte increments



The number in AX is always in multiples of 64 (decimal), up to a maximum of 640.

INT 15h - SW - BIOS EXTENSION

INT 15h is used for a variety of BIOS functions. Table 12-14 provides a summary of BIOS Extension functions.

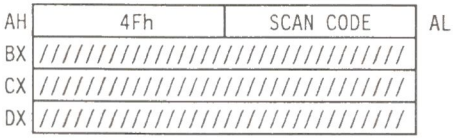
Table 14-14. BIOS Extension Function Summary

AH	Action
4Fh	Keyboard Scan Code Intercept
80h	Device Open
81h	Device Close
82h	Program Terminate
83h	Event Wait
84h	Joystick
85h	SYS REQ Key Routine
86h	Unconditional Wait
87h	Move Block
88h	Expansion Memory Determination
89h	Enter Protected Mode
90h	Device Wait
91h	Device Post
C0h	Return System Environment

INT 15h, AH = 4Fh - KEYBOARD SCAN CODE INTERCEPT

When a keyboard scan code is read from the 8042 by the keyboard BIOS, it invokes INT 15h function 4Fh with the scan code in register AL and the carry flag is set. This allows applications to trap INT 15h to examine and/or modify the scan codes generated by the keyboard. Upon return to the keyboard BIOS if the carry flag has been reset, then the BIOS discards the scan code. Otherwise, the scan code in register AL is encoded as usual.

INPUT:
AH = 4Fh
AL = Scan code received from keyboard
CF = 1

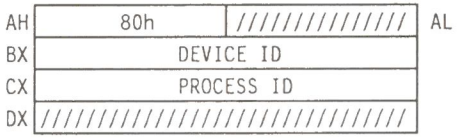


OUTPUT:
If CF = 1
  AL = Scan Code to be used by BIOS
If CF = 0, BIOS discards the scan code

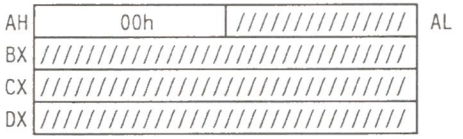
INT 15h, AH = 80h - DEVICE OPEN

INT 15h, AH = 80h is a dummy routine that a user-written dispatcher is expected to trap. The BIOS simply returns with AH = 00h, CF = 0, IF = 1.

INPUT:
AH = 80h
BX = Device ID
CX = Process ID



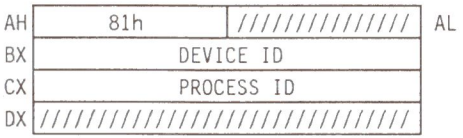
OUTPUT:
AH = 00h
CF = 0, IF = 1



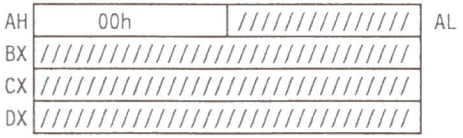
INT 15h, AH = 81h - DEVICE CLOSE

INT 15h, AH = 81h is a dummy routine that a user-written dispatcher is expected to trap. The BIOS simply returns with AH = 00h, CF = 0, IF = 1.

INPUT:
AH = 81h
BX = Device ID
CX = Process ID



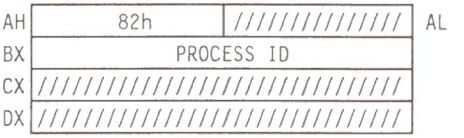
OUTPUT:
AH = 00h
CF = 0, IF = 1



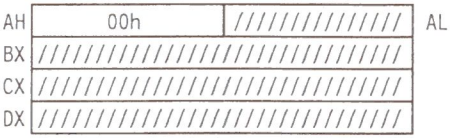
INT 15h, AH = 82h - PROGRAM TERMINATE

INT 15h, AH = 82h is a dummy routine that a user-written dispatcher is expected to trap. This routine serves as a dummy routine for multitasking support. The BIOS simply returns with AH = 00h, CF = 0, IF = 1.

INPUT:
AH = 82h
BX = Process ID



OUTPUT:
AH = 00h
CF = 0, IF = 1



INT 15h, AH = 83h, AL = 00h - EVENT WAIT

A call to INT 15h, AH = 83h always returns immediately. The calling program is expected to poll the semaphore byte to determine completion of the wait period.

INPUT:
AH = 83h
AL = 00h
ES:BX = Pointer to semaphore byte in user memory.
Bit <7> of the semaphore byte is set when the wait time expires
CX = High count of number of microseconds to wait
DX = Low count of number of microseconds to wait

AH	83h	//////00h//////	AL
BX	SEMAPHORE OFFSET		
CX	COUNT <31..16>		
DX	COUNT <15..0>		

ES	SEMAPHORE SEGMENT

OUTPUT:
If CF = 0, no previously defined event is active
IF = 1 (interrupts enabled)

If no previously defined event is active when Event Wait is called, the function call returns with CF = 0. If a previously defined event is still active, the function call returns with CF = 1.

Bit <7> of the user's semaphore byte is not reset by this call prior to performing the Event Wait.

The timing resolution of this call is 976 us since RTC periodic interrupts are used to implement this function.

INT 15h, AH = 83h, AL = 01h - CANCEL EVENT WAIT

This function is used to cancel an Event Wait performed with the function INT 15h, AH = 83h, AL = 00h.
INPUT:
AH = 83h
AL = 01h

AH	83h	01h	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUT: None

INT 15h, AH = 84h - JOYSTICK

INT 15h, AH = 84h reads the joystick switch settings and the joystick potentiometer values. This function assumes that a standard joystick interface is being used. (Refer to the joystick documentation for further information.)

INPUT:
AH = 84h
DX = 0000h - Read Joystick Switches

AH	84h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	0000h		

OUTPUT:
AH = 00h
AL = Switch Settings (bits <7..4>)
CF = 0, IF = 1

AH	00h	SWITCHES	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

BIT
76543210
0000 (Reserved)
Varies (joystick dependent)

INPUT:
AH = 84h
DX = 0001h - Read Joystick POT

AH	84h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	0001h		

OUTPUT:
AX = A(x) (POT) Value
BX = A(y) (POT) Value
CX = B(x) (POT) Value
DX = B(y) (POT) Value
CF = 0, IF = 1

AX	A(x) VALUE
BX	A(y) VALUE
CX	B(x) VALUE
DX	B(y) VALUE

For invalid joystick subfunction codes in DX, the BIOS returns AH = 86h, CF = 1, and IF = 1.

Using a 250-kohm joystick, the range of returned values to be expected for the potentiometers range from a low of 0 to a high of approximately 416 (01A0h). If a game interface is not installed when these functions are invoked, appropriate values are still returned. That is, the values returned for the switches are 1, meaning the buttons are open, and the values returned for the potentiometers are zero.

INT 15h, AH = 85h - SYS REQ KEY ROUTINE

When the SYS REQ key is pressed, the keyboard interrupt handler invokes INT 15h with AH = 85h, AL = 00h. When the SYS REQ key is released, the keyboard interrupt handler invokes INT 15h with AH = 85h, AL = 01h. The BIOS INT 15h Make and Break functions are actually default dummy routines. To make use of the SYS REQ key, system software must trap these functions and provide a handler routine.

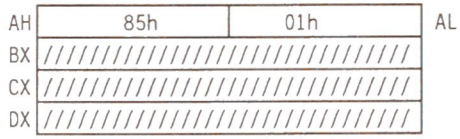
SYS REQ Key Pressed (Make):

INPUT:
AH = 85h
AL = 00h (Make)

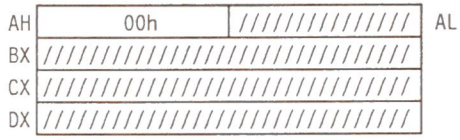
OUTPUT:
AH = 00h
CF = 0, IF = 1

SYS REQ Key Released (Break):

INPUT:
AH = 85h
AL = 01h (Break)



OUTPUT:
AH = 00h
CF = 0, IF = 1

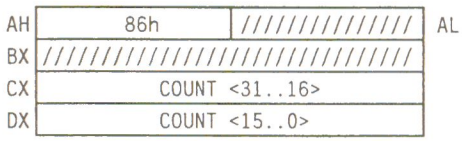


For invalid SYS REQ key subfunction codes in AL, the BIOS returns AH = 00h, CF = 0, and IF = 1.

INT 15h, AH = 86h - UNCONDITIONAL WAIT

INT 15h, AH = 86h performs an unconditional wait. Control does not return to the calling program until the time period has expired.

INPUT:
AH = 86h
CX = High count of number of microseconds to wait
DX = Low count of number of microseconds to wait



OUTPUT:
If CF = 0, the wait was actually performed;
= 1, the wait was not performed, i.e., an Event Wait was currently active
IF = 1 (Interrupts enabled)

If an Event Wait (AH = 83h) is active when this function is called, then the wait is not performed and CF = 1. If an event wait is not active, then the function waits the specified time period and returns with CF = 0.

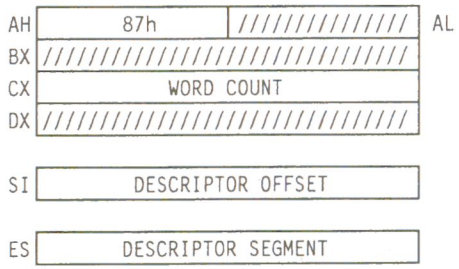
The resolution of this call is 976 us, because RTC periodic interrupts are used to implement this function.

INT 15h, AH = 87h - MOVE BLOCK

INT 15h, AH = 87h moves (copies) a block of data to or from anywhere in physical memory. INT 15h, AH = 87h normally is used to move data to or from expansion memory (past 1 Megabyte) because Real mode addressing can only address the first 1 Megabyte of RAM.

Move Block is performed with interrupts disabled; therefore, the tick counter is not updated during the move.

INPUT:
AH = 87h
CX = Number of words to move (max 8000h)
ES:SI = Pointer to block-move descriptor table



OUTPUT:
AH = 00h if successful, CF = 0, ZF = 1
= 01h if parity error, CF = 1, F = 0
= 02h if exception error, CF = 1, ZF = 0
= 03h if gate address bit A20 fails, CF = 1, F = 0

AH	STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

The following table shows the format of Move-Block Descriptor Table pointed to by the ES:SI registers.

Dummy descriptor	GDT [0]
GDT descriptor	GDT [1]
Source segment descriptor	GDT [2]
Target segment descriptor	GDT [3]
BIOS CS segment descriptor	GDT [4]
BIOS SS segment descriptor	GDT [5]

Entries [0], [1], [4], and [5] should all be initialized by the caller to 8 bytes of 00h each. Entries [2] and [3] must be valid descriptors containing the appropriate base addresses, limit values, and access rights.

INT 15h, AH = 88h - EXPANSION MEMORY DETERMINATION

Returns the amount of memory above 1 megabyte.

INPUT: AH = 88h

AH	88h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUT: AX = Number of 1-Kbyte blocks above 1 megabyte
Flags are unaffected.

AX	EXTENDED MEMORY SIZE
BX	////////////////////////////////
CX	////////////////////////////////
DX	////////////////////////////////

INT 15h, AH = 89h - ENTER PROTECTED MODE

Upon return from the function call, the caller is executing in Protected mode. Address line A20 is enabled, and both Interrupt Controller 1 and Interrupt Controller 2 are reconfigured to use the interrupt base as specified by the user in registers BH and BL, respectively.

Interrupts are disabled at the processor level, and the interrupt mask registers (IMR) of both Interrupt Controller 1 and Interrupt Controller 2 are also disabled upon return. A completion code is returned in register AH. If AH returns with a value of 00h, then the transition to Protected mode has completed successfully. A non-zero value in AH signifies that gate for address line A20 could not be enabled (due to hardware failure) and the caller is still executing in Real mode.

INPUT:
AH = 89h
BH = Interrupt base for IRQ0
BL = Interrupt base for IRQ8
ES:SI = Pointer to descriptor table

AH	89h	////////////////	AL
BH	IRQ0 BASE	IRQ8 BASE	BL
CX	////////////////////////////////		
DX	////////////////////////////////		

SI	DESCRIPTOR OFFSET

ES	DESCRIPTOR SEGMENT

The following table shows the format of Move-Block Descriptor Table pointed to by the ES:SI registers.

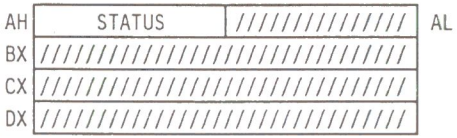
Dummy descriptor	GDT [0]
GDT descriptor	GDT [1]
IDT descriptor	GDT [2]
DS descriptor	GDT [3]
ES descriptor	GDT [4]
SS descriptor	GDT [5]
CS descriptor	GDT [6]
BIOS CS descriptor	GDT [7]

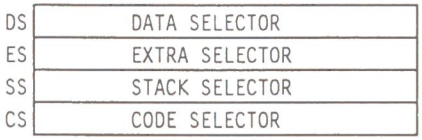
Entries [0] and [7] should be initialized to zeros (null) by the caller. Entry [1] MUST contain the base address and limit for the GDT itself. Entry [2] must be initialized with a base address and a limit that points to an IDT table supplied by the caller. The caller must also supply all interrupt handlers.

Entries [3], [4], and [5] contain the base address, limit, and access rights of the DS, ES, and SS to be used in Protected mode.

The base address of entry [6] should be the caller's code-segment address expressed as a 24-bit base address since the function call expects to return to the instruction following the INT 15h instruction.

OUTPUT:
AH = 00h if OK
= FFh if A20 gate fails
DS = User-defined selector
ES = User-defined selector
SS = User-defined selector
CS = user-defined selector

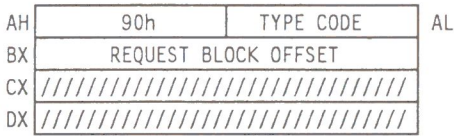




INT 15h, AH = 90h - DEVICE WAIT

INT 15h, AH = 90h can be used for multitasking programming purposes.

INPUT:
AH = 90h
AL = Type code
00h..7Fh Not re-entrant
80h..BFh Re-entrant
C0h..FFh Wait only
ES:BX = Pointer to request block for device types 80h..BFh



OUTPUT:
AH = 00h
CF = 0, IF = 1

AH	00h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

The fixed disk drive, diskette drive, printer, and keyboard ROM drivers all make a call to Device Wait prior to performing a timeout so that a user-written dispatcher can place another task in execution while the device timeout is taking place, therefore achieving better processor throughput.

The ROM device driver tests the CF flag to determine whether the dispatcher has performed the timeout, or if the ROM driver should perform its usual timeout. If CF = 1 upon return from the Device Wait function call, the ROM driver assumes a dispatcher has performed the device timeout, otherwise, the usual timeout is performed by the ROM device driver.

If Device Wait is not trapped by a user-written dispatcher, then its usual function is to return AH = 0, CF = 0, IF = 1, regardless of the type code in AL, effectively telling the ROM driver to perform its own timeout.

INT 15h, AH = 91h - DEVICE POST

This function may be used for multitasking programming purposes.

INPUT:
AH = 91h
AL = Type Code
  00h..7Fh Not re-entrant
  80h..BFh Re-entrant
  C0h..FFh Wait only

ES:BX = Pointer to request block for device types
  80h..BFh

AH	91h	TYPE CODE	AL
BX	REQUEST BLOCK OFFSET		
CX	////////////////////////////////		
DX	////////////////////////////////		

ES	REQUEST BLOCK SEGMENT

OUTPUT:
AH = 00h
Flags unaffected

AH	00h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

This function call is invoked by BIOS device handlers that are interrupt driven, including the fixed disk drive, diskette drive, and keyboard drivers.

The printer BIOS code does not invoke this function since printer devices are not interrupt-driven. The Device Post supplies the mechanism to signal a user-written dispatcher that the device is ready and the task associated with the device can be placed in execution once again.

The BIOS communications functions do not invoke either the Device Wait or the Device Post function call. Although communications I/O is not interrupt driven, timeouts are performed during communications.

If the Device Post function is not trapped by a user-written dispatcher, its usual function is to clear AH and return with the flags unchanged, regardless of the type code supplied in AL.

Table 14-15 is a summary of the Device Post function.

Table 14-15. Device Post Function

Type Code	Class	Description
00h..7Fh	Not Re-entrant	The device and associated ROM code are serially reusable (that is, not re-entrant). It is the responsibility of the user-supplied dispatcher to serialize access within a multitasking environment. An example of this type of device is a diskette drive.
80h..BFh	Re-entrant	The device type is re-entrant, and ES:BX is used to supply the address of a request packet for each of the possibly simultaneous calls. An example of this type of device is an installable device driver for network access.
C0h..FFh	Wait only	This type of device performs timeouts but is not interrupt driven; therefore, Device Waits are executed, but no corresponding Device Post occurs. The length of the timeout is device dependent. The printer is an example of this device type.

When Device Wait and Device Post are invoked by the ROM device drivers, the specific device type is supplied in register AL. Table 14-16 gives the device values for register AL.

Table 14-16. Device Values

Device	AL Value
Fixed Disk Access	00h
Diskette Access	01h
Keyboard	02h
Diskette Motor Start	FDh
Printer	FEh

For fixed disk and diskette accesses, a Device Wait is performed by the BIOS whenever a request is issued to the fixed disk drive controller or diskette drive controller. A Device Post is performed when the controller issues the interrupt signaling the completion of the request. For diskette drive motor start, no interrupt exists that signifies motor start completion, so no corresponding Device Post takes place.

The Get Key keyboard function (INT 16h, AH = 00h) performs a Device Wait if there is currently no character available in the keyboard queue. A Device Post is performed by the keyboard BIOS interrupt handler once a keycode is placed in the keyboard queue.

The Print Character BIOS function (INT 17h, AH = 00h) performs a Device Wait if the printer device is not currently ready to accept a character, and a timeout must be performed.

INT 15h, AH = C0h - RETURN SYSTEM ENVIRONMENT

This function is used to request the system environment from the BIOS. Registers ES:BX return a pointer to a table containing various system configuration parameters. These parameters are not related to the COMPAQ-specific configuration parameters.

INPUT: AH = C0h

OUTPUT: EX:BX = Pointer to system configuration table. System configuration is given is Table 14-17.

Table 14-17. System Configuration Table

Byte in Table	Parameter	Parameter Size	Typical Value
0	Length of table (in bytes)	Word	08h
2	System Model	Byte	FCh
3	System Type	Byte	01h
4	BIOS Revision Level	Byte	00h
5	Misc. Configuration Parameters bit <7> - DMA Channel 3 in use bit <6> - Cascaded Interrupt level 2 bit <5> - Real-time clock available bit <4> - Keyboard intercept available (INT 15h, AH = 4Fh) bits <3..0> - Reserved	Byte	70h
6	Reserved	Byte	00h
7	Reserved	Byte	00h
8	Reserved	Byte	00h
9	Reserved	Byte	00h

INT 18h - SW - BOOT FAIL

When system bootstrap attempts from both the diskette and fixed disk are unsuccessful, an INT 18h is issued by the system ROM.

ROM ENTRY: Points to Boot Fail handler.

ROM ACTION: This vector is initialized by the system ROM to point to the code that outputs a "Diskette error", "Replace and strike any key when ready" message, then waits for the user to press any key. On receipt of a keystroke, a re-boot is attempted by an INT 19h.

USE: The initialization code of a custom ROM can change the INT 18h vector to point to custom-ROM code that attempts to boot from another device, such as a special disk or network. The contents of the INT 18h vector should be preserved. If the attempt to boot the system on another device fails, the custom ROM should transfer control to the standard INT 18h vector. In this manner, the system can follow a sequence of bootstrap attempts on different devices.

INT 19h - SW - BOOTSTRAP

INT 19h reads the bootstrap loader from the system disk and transfers control to it.

ROM ENTRY: Points to Bootstrap ROM entry point.

ROM ACTION: Enables interrupts. Three attempts are then made to read the boot sector into location 0000:7C00. If these fail, INT 18h is called.

INT 02h - HW - NON-MASKABLE INTERRUPT (NMI)

INT 02h occurs when the system detects a memory parity error.

ROM ENTRY: Points to ROM INT 02h handler.

ROM ACTION: When an NMI interrupt occurs, the status of the parity error hardware latch is examined to determine the source of the parity error. The system displays a "Parity Check 2" error message, then halts.

INPUT: State of the hardware parity error latches.

OUTPUT: Video display (if parity error).

14.7 DISKETTE DRIVE INTERRUPTS

All communication between the user and the diskette drive is via a single ROM call (INT 13h). The user can perform any of the following functions: read status, reset diskette, read sectors, write sectors, verify sectors, format a track, get drive parameters, get drive type, get change line status, and set drive and media types for format.The diskette drive BIOS uses INT 0Eh (IRQ6) and DMA Channel 2 of the system. Usage of the diskette drive controller is defined in the diskette drive parameter table.

When the system contains a fixed disk drive, INT 13h interrupts for drive select less than 80h are vectored to INT 40h.

Common Operations

Determining Media

On entry to the diskette-drive routines that access the diskette (read/write/verify), a check is made of the media state for the target diskette drive. If the media state is established, processing continues normally. If the media state is not established, a process internal to the BIOS determines the type of media installed.

DISKETTE CHANGE- is a status signal from the 1.2-megabyte and 720-Kbyte diskette drives that indicates when the drive latch has been opened. This signal is not used on double-density diskette drives.

INT 13h, AH = 16h returns status of the DISKETTE CHANGE- signal of the diskette drive currently selected. On return, AH = 00h, CF = 0, means the DISKETTE CHANGE- signal is inactive (door has not been opened) or AH = 06h, CF = 1, the DISKETTE CHANGE- signal is active (door has been opened).

Whenever an access of the diskette drive for read, write, verify, or format is requested by a BIOS interrupt, the BIOS checks the DISKETTE CHANGE- signal status. If the DISKETTE CHANGE- signal is active (door has been opened), the BIOS checks to see whether the door is still open.

If the door has been closed, a DISKETTE CHANGE- signal off error (AH = 06h) is returned. If the door is still open, an Attachment Failed to Respond error (AH = 80h) is returned.

The media state for the drive (0040:0090 or 0040:0091) is set to unestablished, 48-TPI media in a 1.2-megabyte diskette drive (61h), whenever the drive door is opened. The system then determines the type of media installed with the next diskette access.

Formatting a Diskette

To properly format a diskette, a Set Media Type for Format (INT 13h, AH = 18h) should be made first. This function sets the media state for the diskette drive to "established." If this function call is not made, the format of the diskette is based upon the current media state (established or not) of the diskette drive.

Tables 14-18 and 14-19 respectively, list the BIOS diskette drive interrupts and memory locations used.

Table 14-18. Diskette Drive Interrupts

Interrupts Available	Type	Function
INT 13h	SW	Diskette I/O
INT 40h	SW	Diskette I/O
INT 0Eh	HW	IRQ6, Diskette Interrupt
INT 1Eh	PTR	Diskette Parameter Table

Note: INT 13h is used for fixed disk drive functions. Additional AH functions exist for fixed disk drive interrupts.

Table 14-19. Memory Locations Used by Diskette Drive Interrupts

Memory Location	Bytes	Function
0000:0038	4	INT 0Eh Vector
0000:004C	4	INT 13h Vector
0000:0078	4	INT 1Eh Vector
0000:0100	4	INT 40h Vector
0040:003E	1	Drive Recalibration Status: Set for drives (4..1) if drive needs recalibration Bits <3..0> = drives 4..1 if bit = 0, drive needs recalibration Bit <7> = Interrupt Occurred flag
0040:003F	1	Motor Status bits <3..0> = Drive 4..1 is running
0040:0040	1	Timeout Counter for Drive Motor turns off after 2 seconds of tick counts (37 ticks)
0040:0041	1	Diskette Status
0040:0042	7	Drive Controller Status
0040:008B	1	Data Rate Status <7,6> - Last Data Rate Sent to CNTLR 00 = 500 kbits/s 01 = 300 kbits/s 10 = 250 kbits/s 11 = Reserved <5,4> - Reserved <3,2> - Data rate that operation started with <1> - reserved <0> - 1 = Fixed disk drive controller board installed 0 = Not installed
0040:008F	1	Drive information: A bits: 3 = Reserved; 2 = Multidata rate capability determined; 1 = Multidata format capability; 0 = 80-Track capability B bits: 7 = Reserved; 6 = Multidata rate capability determined; 5 = Multidata format capability; 4 = 80-Track capability
0040:0090	1	Drive 1 (A) Media State Byte
0040:0091	1	Drive 2 (B) Media State Byte
0040:0092	1	Drive 1 (A) Operation Start State

Table 14-19. (Continued)

0040:0093	1	Drive 2 (B) Operation Start State. The Operation Start State is the starting media state when a diskette drive operation begins
0040:0094	1	Drive 1 (A) Current Track Bytes
0040:0095	1	Drive 2 (B) Current Track Bytes

The following bit map shows the format of the diskette drive media state byte defined in memory locations 0040:0090 or 0040:0091.

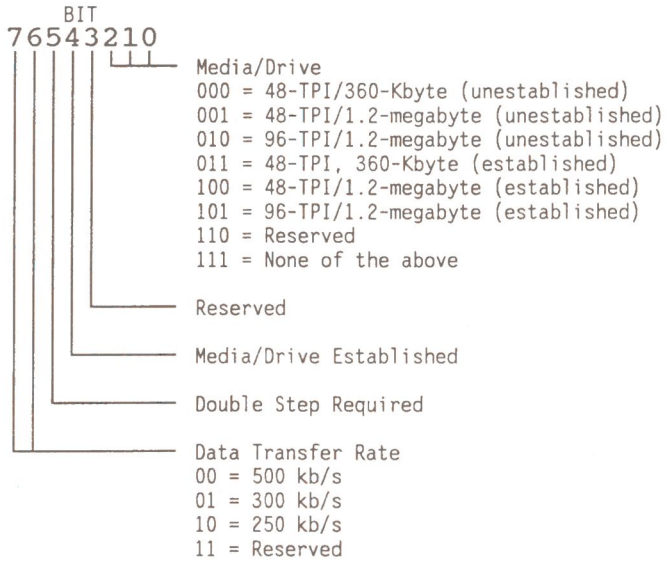


Table 14-20 summarizes possible status codes returned for every possible diskette drive operation (listed by function code in AH).

Table 14-20. Diskette Drive Status Codes Returned

AH	Error Code											
	00h	01h	02h	03h	04h	06h	08h	09h	0Ch	10h	20h	40h	80h
00h	X	X	-	-	-	-	-	-	-	-	-	-	X
01h	X	X	-	-	-	-	-	-	-	-	-	-	-
02h	X	X	X	-	X	X	X	X	-	X	X	X	X
03h	X	X	X	X	X	X	X	X	-	-	X	X	X
04h	X	X	X	-	X	X	X	-	-	X	X	X	X
05h	X	X	X	X	X	X	X	X	-	-	X	X	X
08h	X	X	-	-	-	-	-	-	-	-	-	-	-
16h	X	X	-	-	-	X	-	-	-	-	-	-	X
17h	X	X	-	-	-	X	-	-	-	-	-	-	X
18h	X	X	-	-	-	-	-	-	X	-	-	-	-

Legend: X = status code returned
- = no status code returned

Table 14-21 defines the error codes.

Table 14-21. Definition of Error Codes

Code	Definition
00h	Successful Completion
01h	Bad Command
02h	Address Mark Not Found
03h	Write Protected Media
04h	Requested Sector Not Found
06h	DISKETTE CHANGE- Signal Active
08h	DMA Overrun on Operation
09h	DMA Attempted Across 64K Boundary
0Ch	Track/Sector Combination Not Supported
10h	Bad CRC on Diskette Read
20h	Controller Has Failed
40h	Seek Operation Failed
80h	Drive Failed to Respond

INT 13h - SW - DISKETTE I/O

All communication between the user and the diskette drive is via a single ROM call. The diskette drive BIOS uses INT 0Eh (IRQ6) and DMA channel 2 of the system.

Table 14-22 gives the function summary for Diskette I/O.

Table 14-22. Diskette I/O Function Summary

AH	Function
00h	Reset Disk System
01h	Read Status of Last Operation
02h	Read Sectors
03h	Write Sectors
04h	Verify Sectors
05h	Format Track
08h	Get Drive Parameters
15h	Get Type of Drive
16h	Read Disk Change Line Status
17h	Set Drive Type for Format
18h	Set Media Type for Format

ROM ENTRY: Points to disk I/O routine that dispatches to either the fixed disk (if present) drive BIOS or INT 40h for diskette drive BIOS.

ROM ACTION: Upon entry, control is transferred to one of eleven routines based on the function code in register AH. Illegal function codes cause the routine to report a Bad Command error (01h) and return.

INT 15h, AH = 90h is called when the diskette drive BIOS is waiting for completion of a command.

INT 13h, AH = 00h - RESET DISKETTE DRIVE SYSTEM

INT 13h, AH = 00h resets the diskette drive system.

INPUT:
AH = 00h
DL = Drive Select (0..1)

AH	00h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DH	////////////////	DRIVE	DL

OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error

AH	STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

The Reset Diskette Drive System function call is usually performed after a read, write, verify, or format error before retrying the operation.

INT 13h, AH = 01h - SENSE STATUS OF LAST OPERATION

INT 13h, AH = 01h returns the status of the last disk operation.

INPUT:
AH = 01h
DL = Drive Select (0..1)

AH	01h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DH	////////////////	DRIVE	DL

OUTPUT:
If CF = 0, 00h (Successful Completion)
CF = 1, AH = Status, Operation Error

AH	STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

INT 13h, AH = 02h - READ SECTORS

INT 13h, AH = 02h reads the specified number of sectors into the buffer pointed to by ES:BX.

INPUT:
AH = 02h
AL = Sector Count - Number of sectors to be read by this operation
ES:BX = Buffer Transfer Address
CH = Track (0..39 for 48-TPI media)
(0..79 for 96-TPI and 135-TPI media)
CL = Starting Sector (1..9 for 48-TPI and 135-TPI media)
(1..15 for 96-TPI media)
DH = Head Select (0..1)
DL = Drive Select (0..1)

AH	02h	SECTOR COUNT	AL
BX	BUFFER OFFSET		
CH	TRACK	START SECTOR	CL
DH	HEAD	DRIVE	DL

ES	BUFFER SEGMENT

OUTPUT:
If CF = 0, AH = 00h (Successful Operation)
If CF = 1, AH = Status, Operation Error

AH	STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

The maximum sector count is 18 sectors for 48-TPI and 720-Kbyte 135-TPI media (9 sectors from Head 0, and 9 sectors from Head 1) and 30 sectors for 96-TPI media (15 sectors from Head 0, and 15 sectors from Head 1). The maximum sector count is dependent upon the media type installed.

The diskette drive parameter table (pointed to by INT 1Eh) must reflect the type of media installed for correct operation; that is, the number of sectors per track in the diskette drive parameter table must be 9 for 48-TPI media and 15 for 96-TPI media. Responsibility for the contents of the diskette drive parameter table lies with the user of INT 13h.

INT 13h, AH = 03h - WRITE SECTORS

INT 13h, AH = 03h writes the specified number of sectors onto the diskette using the data pointed to by the ES register.

INPUT:
AH = 03h
AL = Sector Count - Number of sectors to be read by this operation
ES:BX = Buffer Transfer Address
CH = Track (0..39 for 48-TPI media)
(0..79 for 96-TPI and 135-TPI)
CL = Starting Sector (1..9 for 48-TPI and 135-TPI media)
(1..15 for 96-TPI media)
DH = Head Select (0..1)
DL = Drive Select (0..1)

AH	03h	SECTOR COUNT	AL
BX	BUFFER OFFSET		
CH	TRACK	START SECTOR	CL
DH	HEAD	DRIVE	DL

ES	BUFFER SEGMENT

OUTPUT:
If CF = 0 AH = 00h (Successful Completion)
If CF = 1 AH = Status, Operation Error

AH	STATUS	///////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

The maximum sector count is 18 sectors for 48-TPI media (9 sectors from Head 0, and 9 sectors from Head 1) and 30 sectors for 96-TPI media (15 sectors from Head 0, and 15 sectors from Head 1). The maximum sector count is dependent upon the media type installed.

The diskette drive parameter table (pointed to by INT 1Eh) must reflect the type of media installed for correct operation; that is, the number of sectors per track in the diskette drive parameter table must be 9 for 48-TPI media and 15 for 96-TPI media. Responsibility for the contents of the diskette drive parameter table lies with the user of INT 13h.

INT 13h, AH = 04h - VERIFY SECTORS

INT 13h, AH = 04h verifies the specified sectors on the diskette. Sector verification checks the sector ID and other format information for parity errors and data integrity.

INPUT:
AH = 04h
AL = Sector Count - Number of sectors to be verified by this operation
CH = Track (0..39 for 48-TPI media)
(0..79 for 96-TPI and 135-TPI media)
CL = Starting Sector (1..9 for 48-TPI and 720-Kbyte 135-TPI media)
(1..15 for 96-TPI media)
DH = Head Select (0..1)
DL = Drive Select (0..1)

AH	04h	SECTOR COUNT	AL
BX	////////////////////////////////		
CH	TRACK	START SECTOR	CL
DH	HEAD	DRIVE	DL

OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error

AH	STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

The maximum sector count is 18 sectors for 48-TPI media (9 sectors from Head 0, and 9 sectors from Head 1) and 30 sectors for 96-TPI media (15 sectors from Head 0, and 15 sectors from Head 1). The maximum sector count is dependent upon the media type installed.

The diskette drive parameter table (pointed to by INT 1Eh) must reflect the type of media installed for correct operation; that is, the number of sectors per track in the diskette drive parameter table must be 9 for 48-TPI 15 for 96-TPI media. Responsibility for the contents of the diskette drive parameter table lies with the user of INT 13h.

INT 13h, AH = 05h - FORMAT TRACK

INT 13h, AH = 05h writes the sector and track ID information onto the specified tracks.

INPUT:
AH = 05h
ES:BX = Address of track format table (Table 12-23)
CH = Track (0..39 for 48-TPI media)
(0..79 for 96-TPI media)
DH = Head Select (0..1)
DL = Drive Select (0..1)

AH	05h	////////////////	AL
BX	OFFSET OF FORMAT TABLE		
CH	TRACK	////////////////	CL
DH	HEAD	DRIVE	DL

ES	SEGMENT OF FORMAT TABLE

The diskette drive parameter table (pointed to by INT 1Eh) must reflect the type of media installed for correct operation; that is, the numbers of sectors per track in the diskette drive parameter table must be 9 for 48-TPI 15 for 96-TPI media. Responsibility for the contents of the diskette drive parameter table lies with the user of INT 13h. Table 14-23 gives the track format table values.

Table 14-23. Track Format

Offset	Value
+00h	Track
+01h	Head
+02h	Sector 1
+03h	N (bytes per sector) NEC765 parameter
+04h	Track
+05h	Head
+06h	Sector 2
+07h	N (bytes per sector) NEC765 parameter
.	
.	
.	

OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error

AH	STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

Before formatting a diskette, one INT 13h, AH = 18h, Set Media Type for Format function call should be made to set the media type for format.

INT 13h, AH = 08h - READ DRIVE PARAMETERS

INT 13h, AH = 08h returns the diskette drive parameters. For the drive selected.

INPUT: AH = Function Code = 08h
DL = Drive Select (0..1)

AH	08h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DH	////////////////	DRIVE	DL

OUTPUT: AX = 00h
BH = 00h
BL = 3..0 - Valid drive type value in CMOS
CH = Low-order eight bits of (10-bit) maximum number of tracks
CL = 7..6 - High-order two bits of maximum number of tracks
5..0 - Maximum number of sectors per track
DH = Maximum head number
DL = Number of diskette drives installed
ES:DI = Pointer to Diskette Parameter Table

The CMOS drive type value as well as the maximum number of tracks allowed for the specified drive are returned. The number of sectors per track, the maximum number of heads, and a pointer to the correct diskette parameter table are also given.

If input is bad (invalid input or drive type unknown or bad CMOS):

AX = 00h
BX = 00h
CX = 00h
DH = 00h
DL = Number of diskette drives installed

NOTE: The values given reflect the capacity of the diskette drive; they do not represent characteristics of the media installed.

AX		////////////////	AL
BH	00h	CMOS TYPE	BL
CH	MAX. # OF TRACKS	# SEC./TRACK	CL
DH	MAX. HEAD	# DRIVES	DL

DI	DISKETTE TABLE OFFSET

ES	DISKETTE TABLE SEGMENT

INT 13h, AH = 15h - GET TYPE OF DRIVE

INT 13h, AH = 15h returns the drive type for the specified drive.

INPUT: AH = 15h
DL = Drive Select (0..1, 80h..81h)

AH	15h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DH	////////////////	DRIVE	DL

OUTPUT: If CF = 0, AH = Type of Drive
If CF = 1, Bad Command (Invalid Drive)

AH	TYPE OF DRIVE	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

Table 14-24 lists the AH register values for drive types:

Table 14-24. AH Register Values

AH	Definition
00h	Drive not installed
01h	Diskette drive without DISKETTE CHANGE- signal
02h	Diskette drive with DISKETTE CHANGE- signal
03h	Fixed disk drive

INT 13h, AH = 16h - GET DRIVE DISKETTE CHANGE-SIGNAL STATUS

INT 13h, AH = 16h returns the status of the DISKETTE CHANGE- signal from the specified diskette drive.

INPUT:
AH = 16h
DL = Drive Select (0..1)

AH	16h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DH	////////////////	DRIVE	DL

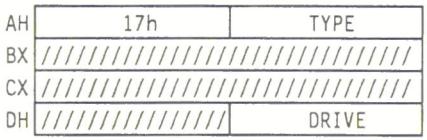
OUTPUT:
If CF = 0, AH = 00h DISKETTE CHANGE- signal inactive (door has not been opened)
If CF = 1, AH = 01h Bad command (invalid drive)
If CF = 1, AH = 06h DISKETTE CHANGE- signal active (door has been opened)

AH	STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

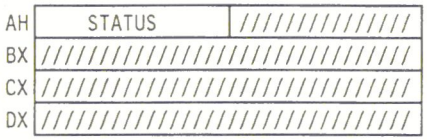
INT 13h, AH = 17h - SET DRIVE TYPE FOR FORMAT

INT 13h, AH = 17h specifies the type of diskette drive currently in the diskette drive position (0 or 1).

INPUT: AH = 17h
AL = Drive Type
01h - 360 Kbyte diskette drive
02h - 48-TPI media in 1.2-megabyte diskette drive
03h - 96-TPI media in 1.2-megabyte diskette drive
DL = Drive Select (0..1)



OUTPUT: If CF = 0, AH = 00h, (Successful Completion)
If CF = 1, AH = 01h, Bad Command (Invalid Drive)

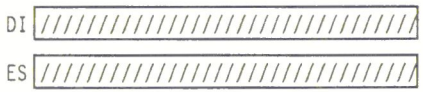


Before formatting a diskette, one INT 13h, AH = 17h call should be made to set the diskette type for format.

INT 13h, AH = 18h - SET MEDIA TYPE FOR FORMAT

INT 13h, AH = 18h sets up the parameters of the media currently installed in the diskette drive position (0 or 1). This function can be used instead of function 17h, Set Drive Type for Format, to set up the needed parameters for the Format Track command (function 05h).

INPUT: AH = Function code = 18h
CH = Low-order 8 bits of (10-bit) maximum number of tracks
CL = <7..6> - High-order 2 bits of maximum number of tracks
DL = Drive select (00h..01h)



OUTPUT: If CF = 0, AH = 00h (Successful Completion)
ES:DI - pointer to Diskette Parameter Table
IF CF = 1, AH = 01h, Bad Command (Function not available)

AH	00h	////////////////	AL
BX	////////////////////////////////		
CH	MAX. # OF TRACKS	# SEC./TRACK	CL
DH	////////////////	DRIVE	DL

DI	DISKETTE TABLE OFFSET

ES	DISKETTE TABLE SEGMENT

INT 40h - SW - DISKETTE DRIVE I/O

Calls to INT 13h for diskette drive operations (as determined by the drive value in register DL) are vectored to INT 40h for actual diskette drive BIOS processing. Therefore, INT 40h behaves identically to INT 13h when used for diskette drive operations if the system contains a fixed disk drive. Please refer to INT 13h for information on all INT 40h functions.

INT 0Eh - HW - IRQ6, DISKETTE DRIVE INTERRUPT

INT 0Eh is initiated by the diskette drive controller at the completion of an operation.

ROM ENTRY: Points to ROM Diskette Drive Interrupt handler.

ROM ACTION: Calls made to the ROM using INT 13h for diskette drive I/O are suspended internally until INT 0Eh occurs, signifying completion.

USE: The vector for this interrupt can be changed to intercept diskette drive I/O operations for special real-time operating system requirements.

INT 1Eh - PTR - DISKETTE DRIVE PARAMETER TABLE VECTOR

The vector for this interrupt points to the Diskette Drive Parameter Table, which is summarized in Table 14-25. The Diskette Drive Parameter table is used to program the diskette drive controller chip (NEC765 or Intel 8272). Please refer to either the NEC765 or Intel 8272 disk controller specification for more information.

Table 14-25. Diskette Drive Parameter Table (All values in hexadecimal)

Parameter	360-Kbyte Diskette Drive	48-TPI Media in a 1.2-Megabyte Diskette Drive	96-TPI Media in a 1.2-Megabyte Diskette Drive
Step Rate (SRT)/ Head Unload Time (HUT)	DF	DF	DF
Head Load Time/DMA	02	02	02
Motor Off Time	25	25	25
Sector Length	02	02	02
Sectors/Track	09	09	0F
Gap Length, Normal	2A	2A	1B
DTL	FF	FF	FF
Gap Length, Format	50	50	54
Fill Character, Format	F6	F6	F6
Head-Settle Time (Note 1)	0F	0F	0F
Motor-Settle Time (Note 1)	08	08	08
Maximum Track Value	27	27	4F
Date Transfer Rate (Note 2)	80	40	00

Notes: 1. During a write operation, if the Diskette Drive Parameter Table specifies a head-settle time of less than 20 ms for a double-density diskette drive, then 15/20 ms is used. In addition, a motor-settle time of 1 second is used for a write or format operation and 625 ms for a read or verify operation.

2. 80h -- 250-kbit/second
   40h -- 300-kbit/second
   00h -- 500-kbit/second

14.8 PRINTER INTERRUPTS

The Printer BIOS provides a simplified interface to the parallel printer ports. Functions are provided for initializing a printer, printing characters, and reading the printer status.

Printer BIOS operation is not interrupt-driven; however, a Device Wait interrupt (INT 15h, AH = 90h, AL = FEh) is supported internally and is executed if the printer is not ready when the Print Character function is called. Printer interrupt IRQ7 (INT 0Fh) is available for systems software.

During power-on, the BIOS searches for parallel printer interfaces at three standard port locations (3BCh, 378h, and 278h). When an interface is found, the BIOS places the printer port base address in BIOS memory, beginning at 0040:0008. Therefore, when programming a printer port, recommended practice is to use the address extracted from the table in BIOS memory instead of a hardcoded address.

In addition to being directly callable by applications software, the Print Screen function (INT 05h) is invoked by the keyboard BIOS when both the SHIFT and PRTSC keys are pressed simultaneously. INT 05h repeatedly invokes INT 17h for each character. Characters in every position on the screen are sent to the printer without suppressing trailing blanks. A flag in BIOS RAM at location 0040:0100 contains the Print Screen status.

Printer BIOS provides a timeout function whose length is programmable by the user. A four-byte table in BIOS memory beginning at 0040:0078 is reserved for setting the timeout values for each parallel printer port. These timeout values are initialized to 20 during power-on, and may be set from 1 to 255. Each increment is approximately 1 second.

Table 14-26 lists the BIOS printer interrupts. Table 14-27 lists the memory locations used.

Table 14-26. Printer Interrupts

Interrupt	Type	Function
INT 05h	SW	Print Screen
INT 17h	SW	Printer I/O
INT 0Fh	HW	IRQ7, Printer Interrupt

Table 14-27. Memory Locations Used by Printer Interrupts

Memory Location	Bytes	Function
0000:0014	4	INT 05h Vector
0000:003C	4	INT 0Fh Vector
0000:005C	4	INT 17h Vector
0040:0008	2	Base Address of Printer Port 0
0040:000A	2	Base Address of Printer Port 1
0040:000C	2	Base Address of Printer Port 2
0040:000E	2	Base Address of Printer Port 3
0040:0078	1	Timeout for Printer Port 0
0040:0079	1	Timeout for Printer Port 1
0040:007A	1	Timeout for Printer Port 2
0040:007B	1	Timeout for Printer Port 3
0040:0100	1	Print Screen Status

INT 05h - SW - PRINT SCREEN
- CPU - BOUND EXCEEDED

INT 05h is initiated by explicitly executing an INT 05h instruction (for Print Screen), or by exceeding the limits specified in the Bound Exceeded instruction. INT 05h is called to perform a text Print Screen function using INT 10h function calls for handling the screen and INT 17h function calls for outputting to the printer.

ROM ENTRY: Points to ROM Print Screen handler.

ROM ACTION: Interrupt routine is used by the ROM keyboard handler when the SHIFT + PRTSC keys are pressed on an 84-key keyboard, or the PRINT SCREEN key is pressed on the COMPAQ Enhanced keyboard. INT 05h uses INT 10h to read the screen and INT 17h to send characters to the printer.

When INT 05h is called, the current cursor position is saved. The cursor position is restored when the printing is complete. Address 0040:0100 contains the status of the Print Screen operation; 00h = Print Screen Not In Operation (or successful completion of a print screen call); 01h = Print Screen Is In Progress. A value of FFh is returned if a timeout is detected. If the printer is off line or is not ready, the Print Screen function times out in one character time.

If another Print-Screen call is attempted while a print screen is in progress, it is ignored. Trailing spaces are not compressed. All registers are preserved. INT 05h runs with interrupts enabled.

When printing is complete, the cursor position is restored. Trailing spaces are not compressed. All registers are preserved across the call.

USE: An applications program may use the interrupt to request a hardcopy of the display. This vector is normally changed for enhanced screen functions such as handling graphics screens, special printers, and redirecting output to files.

A replacement INT 05h handler can determine the source of the interrupt by examining the 2 bytes previous to the instruction pointed to by the return address on the stack. If the bytes are CDh, 05h, then the source of the interrupt is an INT 05h.

The Print Screen function conforms to the printer timeout variables the same way as the Print Screen function.

INT 17h - SW - PRINTER I/O

INT 17h is called to perform all functions related to printer I/O.

ROM ENTRY: Points to Printer I/O ROM entry point.

ROM ACTION: Upon entry, control is transferred to one of three routines (listed below) based on the function code in register AH. Illegal function codes cause control to simply return. All registers except those returning a value are preserved. Table 14-28 gives the function summary of the Printer I/O.

Table 14-28. Function Summary

AH	Function
00h	Print Character
01h	Initialize
02h	Get Status

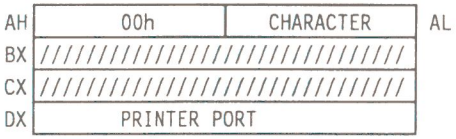
Interrupts remain enabled.

Functions and their related parameters are individually described on the following pages.

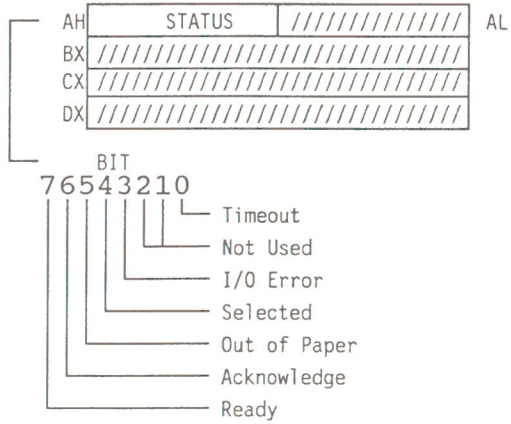
INT 17h, AH = 00h - PRINT CHARACTER

INT 17h, AH = 00h writes the specified character to the printer.

INPUT:
AH = 00h
AL = Character to be printed (00h..FFh)
DX = Printer Port Number (0..3)



OUTPUT:
AH = Status



The return status for some typical operations is given below:

Status: AH = 10h (From normal operation)
AH = 00h (Base Address = 0000h)

Some printers return with bit <3> = 1 when off line.

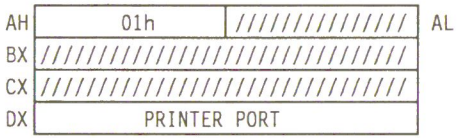
INT 15h, AH = 90h is performed when the print character function is called but the printer is not ready.

INT 17h, AH = 01h - INITIALIZE PRINTER

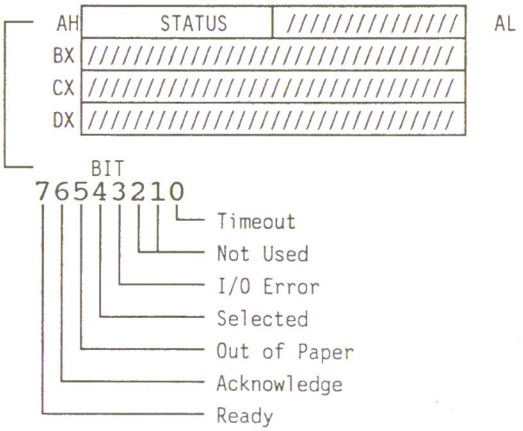
INT 17h, AH = 01h initializes the printer, then polls the printer for the printer status and places the printer status in the AL register.

INPUT: AH = 01h

DX = Printer Port Number (0..3)



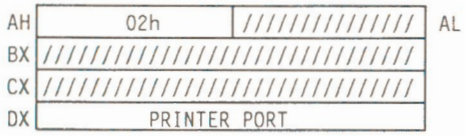
OUTPUT: AH = Status
= 00h (From normal operation)
= 01h (Base Address = 0000h)



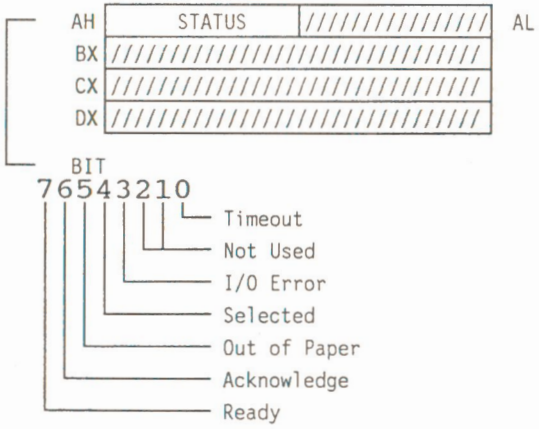
INT 17h, AH = 02h - GET PRINTER STATUS

INT 17h, AH = 02h polls the printer for the printer status and places this value in the AL register.

INPUT: AH = 02h
DX = Printer Port Number (0..3)



OUTPUT: AH = Status



Typical return statuses are listed below in Table 14-29.

Table 14-29. Return Statuses

AH	Description
00h	Offline
02h	Read (Base address = 0)
08h	Power Off, Cable On
30h	Cable Off
90h	Read Status After Print
BBh	Port Init (no printer port installed)

Some printers return with bit <3> = 1 when offline.

INT 0Fh - HW - IRQ7, PRINTER INTERRUPT

INT 0Fh is not used.

ROM ENTRY: Points to a dummy interrupt return.

ROM ACTION: Returns.

INPUT: None.

OUTPUT: None.

USE: The vector for this interrupt may be changed to intercept printer character interrupts for special real-time operating system requirements, such as print spooling.

14.9 ASYNCHRONOUS COMMUNICATIONS INTERRUPTS

The asynchronous communications interrupts provide a simplified interface to the asynchronous communications ports. Functions are provided for initializing a serial port, transmitting characters, receiving characters and reading status.

Asynchronous communications are not hardware interrupt-driven. There are two device-oriented interrupts IRQ4 (INT 0Ch) for the primary port and IRQ3 (INT 0Bh) for the secondary port.

During power-on, the BIOS searches for asynchronous communication ports at two standard port locations (3F8h and 2F8h). When a serial port is found, its base address is placed in the BIOS memory, beginning at 0040:0000. Therefore, when programming a serial port, the recommended practice is to use the address extracted from the table in BIOS memory instead of a hardcoded address.

The BIOS provides a serial-port timeout function whose length is programmable by the user. A 4-byte table in BIOS memory beginning at 0040:007C is reserved for setting the timeout values for each serial port. These timeout values are initialized to 1 during power-on, and can be set to a maximum of 255. Each increment is approximately 900 ms.

Table 14-30 lists the BIOS asynchronous communications interrupts. Table 14-31 lists the memory locations used.

Table 14-30. Asynchronous Communications Interrupts

Interrupts Available	Type	Function
INT 14h	SW	Asynchronous Communications
INT 0Bh	HW	IRQ3, Comm, Secondary
INT 0Ch	HW	IRQ4, Comm, Primary

Table 14-31. Memory Locations Used by Asynchronous Communications Interrupts

Memory Location	Bytes	Function
0000:002C	4	INT 0Bh Vector
0000:0030	4	INT 0Ch Vector
0000:0050	4	INT 14h Vector
0040:0000	2	Base Address of Comm Port 0
0040:0002	2	Base Address of Comm Port 1
0040:0004	2	Base Address of Comm Port 2
0040:0006	2	Base Address of Comm Port 3
0040:0071	1	Break Bit
0040:007C	1	Timeout for Comm Port 0
0040:007D	1	Timeout for Comm Port 1
0040:007E	1	Timeout for Comm Port 2
0040:007F	1	Timeout for Comm Port 3

INT 14h - SW - COMMUNICATIONS I/O

INT 14h is called to perform all functions related to I/O on the RS-232-C serial ports.

ROM ENTRY: Points to Communications I/O ROM entry point.

ROM ACTION: Upon entry, control is transferred to one of four routines (listed below) based on the function code in register AH. Illegal function codes cause control to simply return to the calling program. All registers except those returning a value are preserved. Table 14-32 gives the function summary of Communications I/O.

Table 14-32. Communication I/O

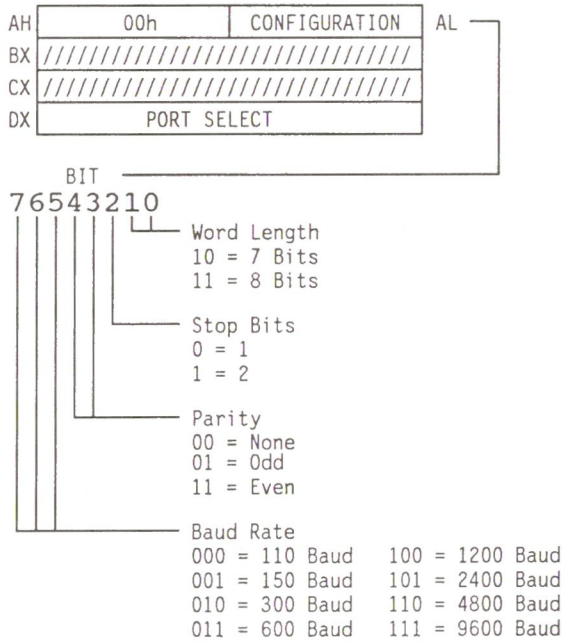
Function Summary	
AH	Action
00h	Initialize Port
01h	Transmit Character
02h	Receive Character
03h	Sense Status

Interrupts remain enabled. The interrupt mask for the communication interrupts and the control port for the asynchronous serial communications interrupts are not affected.

INT 14h, AH = 00h - INITIALIZE PORT

INT 14h, AH = 00h specifies the word length, number of stop bits, type of parity, and baud rates for the specified port.

INPUT: AH = 00h
AL = Port Configuration
DX = Communications Port Select (0..3)



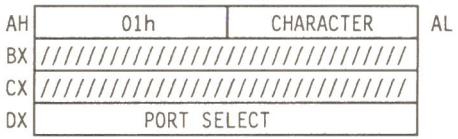
OUTPUT: None.

Even though the BIOS supports four communication ports, the initialization only supports port 0 and port 1. To use port 2 and port 3, the user must install the base addresses of the communication port in memory locations 0040:0004 and 0040:0006.

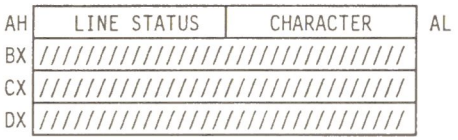
INT 14h, AH = 01h - TRANSMIT CHARACTER

INT 14h, AH = 01h outputs a character to the specified serial communication port.

INPUT:
AH = 01h
AL = Character to be Transmitted (00h..FFh)
DX = Communications Port Select (0..3)



OUTPUT: AH = LINE Status Register
(See function 03h, Sense Communications Status, for definition.)



INT 14h, AH = 02h - RECEIVE CHARACTER

INT 14h, AH = 02h reads the specified serial port receiver buffer and places the character value and universal asynchronous receiver/transmitter line status in the output registers.

INPUT:
AH = 02h
DX = Communications Port Select (0..3)

AH	02h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	PORT SELECT		

OUTPUT:
AH = LINE Status Register (See Function 03h, Sense communications Status, for definition.)
AL = Character Received, if no error
= 00h, if error

AH	LINE STATUS	CHAR/STATUS	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

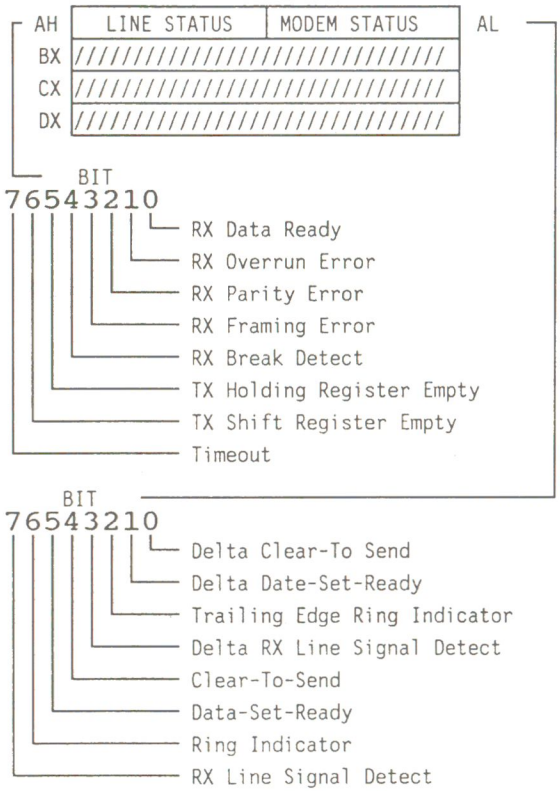
INT 14h, AH = 03h - SENSE COMMUNICATIONS STATUS

INT 14h, AH = 03h reads the specified serial port modem and line status values and places these values in the output registers.

INPUT:
AH = 03h
DX = Communications Port Select (0..3)

AH	03h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	PORT SELECT		

OUTPUT:
AH = Line Status
AL = Modem Status



INT 0Bh - SW - IRQ3, COMM, SECONDARY

INT 0Bh is not used.

ROM ENTRY: Points to Dummy Interrupt Return.

ROM ACTION: Control returns to the calling program.

INPUT: None.

OUTPUT: None.

USE: The vector for this interrupt can be changed to intercept interrupts from an optional secondary communications interface.

INT 0Ch - HW - IRQ4, COMM, PRIMARY

INT 0Ch is not used.

ROM ENTRY: Points to Dummy Interrupt Return.

ROM ACTION: Control returns to the calling program.

INPUT: None.

OUTPUT: None.

USE: The vector for this interrupt can be changed to intercept interrupts from an optional primary communications interface.

14.10 KEYBOARD INTERRUPTS

The BIOS generally controls all interactions with the keyboard. However, the interrupts and memory locations used for the keyboard make it very easy to change the keyboard functions.

SYS REQ Key

The SYS REQ key is a special key. It is not encoded, nor is anything placed in the keyboard queue when it is pressed.

Pressing the SYS REQ key invokes INT 15h with AH = 85h, AL = 00h (SYS REQ Make code). Releasing the SYS REQ key invokes INT 15h with AH = 85h, AL = 01h (SYS REQ Break code).

The SYS REQ key does not interact with any other key and is not repeating. An application must trap INT 15h in order to make use of the SYS REQ key.

RAM location 0040:0018 stores the SYS REQ key status. If bit <2> in the status byte at 0040:0018 is set, this means that the SYS REQ key is currently held down. The bit is cleared when the SYS REQ key is released.

Keyboard Indicators

The BIOS normally controls the state of the keyboard LED indicators. It automatically changes the state of the LED indicators to reflect the current status of CAPS LOCK, NUM LOCK, and SCROLL LOCK keyboard functions.

All communications to the keyboard occur through ports 60h and 64h of the 8042 keyboard controller.

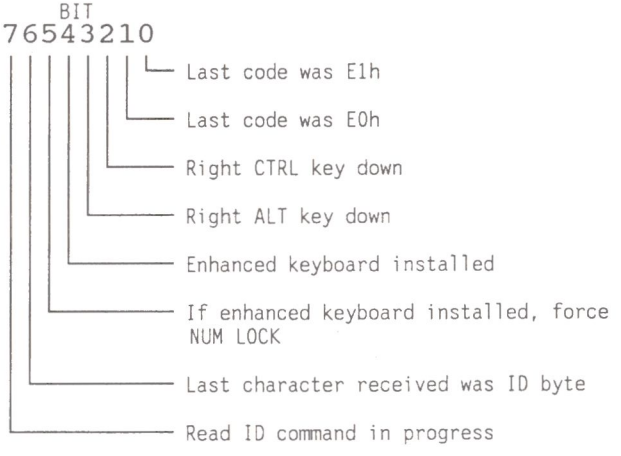
To change the keyboard LED state, use the IN and OUT instructions of the 80286 to:

1. Read port 64h to determine the input/output status of the 8042, making sure the input buffer is empty.
2. Write the Disable Keyboard (ADh) command to port 64h to disable the keyboard interface. Read the scan code from port 60h.
3. Wait until the 8042 input buffer is empty. Output EDh to the keyboard assembly using port 60h. Wait until an ACK (the first of two ACK bytes) is received from port 60h.
4. When the 8042 input buffer is empty, write the LED data byte. Wait until the second ACK byte is received. When the 8042 buffer is empty, write the Enable Keyboard (AEh) command to the 8042 to re-enable the keyboard interface.

Enhanced Keyboard

A RAM variable at 0040:0096 is used in conjunction with the COMPAQ Enhanced Keyboard for state information.

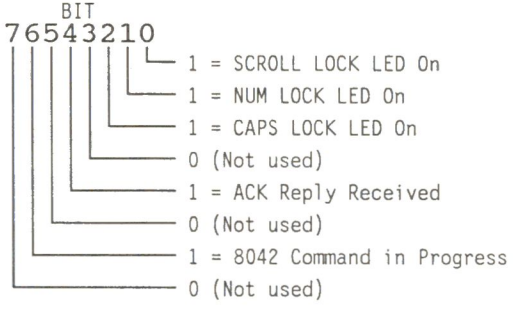
The format of RAM location 0040:0096 (byte) is defined below:



A RAM variable at 0040:0097 reflects the state of the keyboard LED indicators. The LED indicators are controlled by the keyboard BIOS through the use of commands issued to the 8042 keyboard controller.

The information in 0040:0097 is compared with the mode bits in 0040:0017 to determine whether the LED indicators are up to date.

The format of RAM location 0040:0097 (byte) is defined below:


BIT
76543210
1 = SCROLL LOCK LED On
1 = NUM LOCK LED On
1 = CAPS LOCK LED On
0 (Not used)
1 = ACK Reply Received
0 (Not used)
1 = 8042 Command in Progress
0 (Not used)

The status of the LED indicators are checked:

- Each time a keyboard hardware interrupt occurs
- When invoking the Get Key (INT 16h, AH = 00h or AH = 10h) function
- When invoking the Check For Key Available (INT 16h, AH = 01h or AH = 11h) function

The ability to vary keyclick loudness is a BIOS feature unique to Compaq. Two RAM locations are associated with the keyclick:

Address	Bytes	Contents
0040:0015	1	Previous Scan Code
0040:0016	1	Keyclick Loudness (0..127)

Miscellaneous BIOS Keyboard Information

Immediately after placing a key in the keyboard queue, INT 15h is called with AH = 91h, AL = 02h. (See Device Wait and Device Post under INT 15h functions.)

Keys and key combinations that do not cause anything to be placed in the keyboard queue (such as simply pressing the CAPS LOCK key and releasing it) do not cause a Device Post. Pause (CTRL + NUM LOCK) does not perform either a Device Wait or a Device Post.

Decimal keyboard codes can be entered by holding down the ALT key, entering the number on the numeric keypad, then releasing the ALT key. This feature works regardless of the state of the NUM LOCK key. For example, to enter the pi character, hold down the ALT key, type "227" on the numeric keypay, and then release the ALT key.

The Get Key function (INT 16h, AH = 00h or AH = 10h) executes a Device Wait (INT 15h, AH = 90h, AL = 02h) if a keycode is not currently available in the keyboard queue.

The following key combinations do not place scan codes in the keyboard type-ahead buffer:

- Increase keyclick loudness (CTRL + ALT + Numeric Keypad "+")
- Decrease keyclick loudness (CTRL + ALT + Numeric Keypad "-")
- Internal/External display select (CTRL + ALT + > and CTRL + ALT + <)
- Toggle underlining on current display character (CTRL + ALT + _ (underscore))

For receive timeout errors, parity errors, and overrun errors, the 8042 places a scan code of FFh in its output buffer. The system beeps once when it receives the FFh from the keyboard.

For transmit timeout errors, the 8042 places a scan code of FEh in its output buffer.

Interrupts remain enabled and execution is suspended if CTRL + NUM LOCK is input.

Table 14-33 lists the BIOS keyboard interrupts.

Table 14-33. Keyboard Interrupts

Interrupts Available	Type	Function
INT 16h	SW	Keyboard I/O
INT 1Bh	SW	Ctrl-Break Service
INT 09h	HW	IRQ1, Keyboard Interrupt

Table 14-34 lists the memory locations used by keyboard interrupts.

Table 14-34. Memory Locations Used by Keyboard Interrupts

Memory Location	Bytes	Function
0000:0024	4	INT 09h Vector
0000:0058	4	INT 16h Vector
0000:0066	4	INT 1Bh Vector
0040:0015	1	Previous Scan Code
0040:0016	1	Keyclick Loudness
0040:0017	2	Keyboard Bit Status
0040:0019	1	Accumulator for ALT Key Input
0040:001A	2	Keyboard Buffer Pointer-Head
0040:001C	2	Keyboard Buffer Pointer-Tail
0040:001E	32	Keyboard Type-Ahead Buffer (16 entries)
0040:0071	1	Break Bit
0040:0080	2	Keyboard Buffer Begin
0040:0082	2	Keyboard Buffer End
0040:0096	1	Enhanced Shift Status
0040:0097	1	Keyboard LED Flags

INT 16h - SW - KEYBOARD I/O

INT 16h is called to perform all functions related to Keyboard I/O.

ROM ENTRY: Points to keyboard I/O ROM entry point.

ROM ACTION: Upon entry, control is transferred to one of seven routines (listed below) based on the function code in register AH. Illegal function codes cause control to simply return to the calling program. All registers except those returning a value are preserved. Interrupts remain enabled. Table 14-35 gives the function summary of the Keyboard I/O.

Table 14-35. Keyboard I/O Function Summary

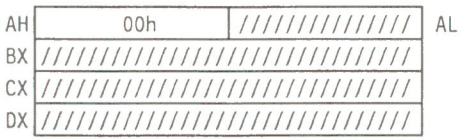
Register AH	Function
00h	Get Key
01h	Check for Key Available
02h	Read Shift Status
03h	Set Repeat Key Rate and Delay
05h	Place Scan Code/Character in Type-Ahead Buffer
10h	Get Enhanced Key from Type-Ahead Buffer
11h	Check for Enhanced Key from Type-Ahead Buffer
12h	Get Enhanced Key Status
F0h	Set CPU Speed
F1h	Read Current CPU Speed
F2h	Determine Attached Keyboard

INT 16h, AH = 00h - GET KEY

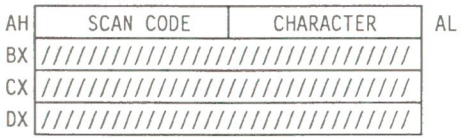
INT 16h, AH = 00h reads a scan code/character pair from the keyboard BIOS type-ahead buffer and returns it to the calling program. If no key is available in the type-ahead buffer, this function waits until a key is pressed before returning control to the program performing the function. If the application program does not wish to wait for keys to be pressed, function AH = 01h should be performed to determine whether any characters exist in the type-ahead buffer before attempting to get them using the AH = 00h function.

INT 16h, AH = 00h

INPUT: AH = 00h



OUTPUT:
AH = Scan Code
AL = Character

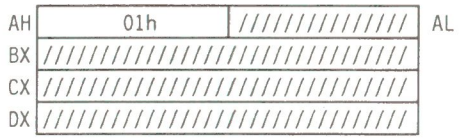


INT 16h, AH = 01h - CHECK FOR KEY AVAILABLE

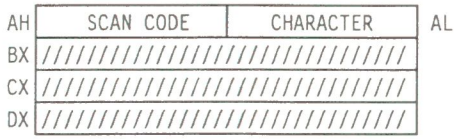
INT 16h, AH = 01h should be performed to determine whether any key scan codes are present in the keyboard BIOS type-ahead buffer. If a scan code/character is present, it is not removed from the type-ahead buffer.

INT 16h, AH = 01h. Checks keyboard buffer.

INPUT: AH = 01h



OUTPUT:
ZF = Result
= 1 - No keys available
= 0 - Key available
AH = Scan Code
AL = Character



The character is not removed from the keyboard input buffer.

INT 16h, AH = 02h - READ SHIFT STATUS

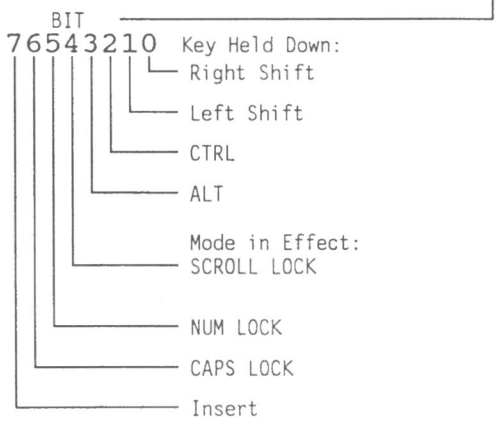
INT 16h, AH = 02h returns the SHIFT status byte.

INPUT: AH = 02h

AH	02h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUT: AL = Shift Codes

AH	////////////////	SHIFT CODES	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		



INT 16h, AH = 03h - SET REPEAT KEY RATE AND DELAY

INT 16h, AH = 03h is used to set the repeat key rate and delay for all repeat keys on the keyboard. The delay value placed in BH should not exceed 3. The repeat rate value in BL should not exceed 63 (decimal). If these values are beyond their allowed limits, the repeat rate and delay are not set.

INPUT: AH = 03h
AL = 05h
BH = Repeat delay (1...63)
BL = Repeat rate

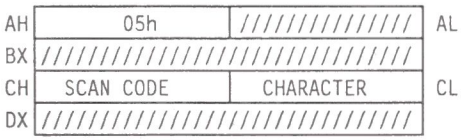
AH	03h	05h	AL
BH	REPEAT DELAY	REPEAT RATE	BL
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUT: None, flags are unaffected.

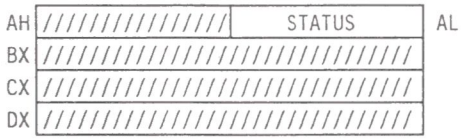
INT 16h, AH = 05h - PLACE SCAN CODE/CHARACTER IN TYPE-AHEAD BUFFER

INT 16h, AH = 05h places the scan code and character specified in CH and CL in the keyboard BIOS type-ahead buffer.

INPUT: AH = 05h
CH = Scan code
CL = Character



OUTPUT:
AL = 00h, CF = 0, if scan code and character are placed in type-ahead buffer.
AL = 01h, CF = 1, if type-ahead buffer is full, and the scan code and character are not placed in the type-ahead buffer.

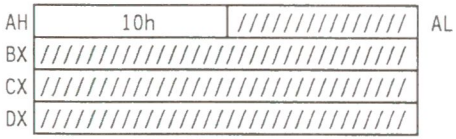


INT 16h, AH = 10h - GET ENHANCED KEY FROM TYPE-AHEAD BUFFER

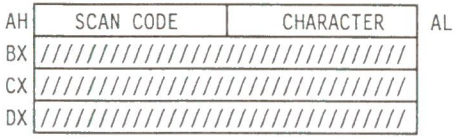
INT 16h, AH = 10h reads a scan code/character pair from the keyboard BIOS type-ahead buffer. If no key is available in the type-ahead buffer, this function waits until a key is pressed before returning control to the program performing the function. If the application program does not wish to wait for keys to be pressed, function AH = 11h should be performed to determine whether any characters exist in the type-ahead buffer before attempting to get them using the AH = 10h function.

This function should be used instead of function AH = 00h if the enhanced keyboard is used in Mode 2. This function allows applications to obtain the scan codes for the additional keys in the enhanced keyboard. These keys include F11, F12, and the keys in the cursor control cluster. (See Chapter 5, Keyboard, for scan codes generated by the 84-key and enhanced keyboards.)

INPUT: AH = 10h



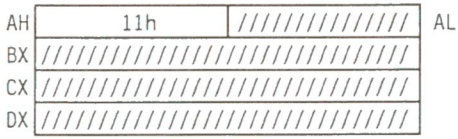
OUTPUT: AH = Scan code
AL = Character



INT 16h, AH = 11h - CHECK FOR ENHANCED KEY IN TYPE-AHEAD BUFFER

INT 16h, AH =11h should be performed to determine whether any key scan codes are present in the keyboard BIOS type-ahead buffer. If a scan code/character is present, it is not removed from the type-ahead buffer. This function should be used instead of function AH = 01h if the enhanced keyboard is used in Mode 2. This function allows applications to obtain via the BIOS the scan codes for the additional keys in the enhanced keyboard. These keys include F11, F12, and the keys in the cursor control cluster. (See Chapter 5, Keyboard, for the scan codes generated by the 84-key and enhanced keyboards.)

INPUT: AH = 11h

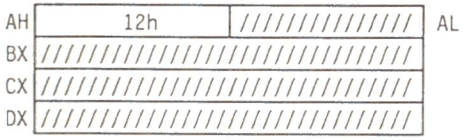


OUTPUT: If ZF = 1, no scan codes are in the type-ahead buffer.
If ZF = 0, then AH = first scan code present in the type-ahead buffer, and
AL = first character present in type-ahead buffer.

INT 16h, AH = 12h - GET ENHANCED KEY STATUS

INT 16h, AH = 12h returns the status of several enhanced keyboard functions and keys. This function should be used instead of function AH = 02h when using the enhanced keyboard in Mode 2. In Mode 2, this function allows applications to obtain the status of the additional ALT and CTRL keys of the enhanced keyboard.

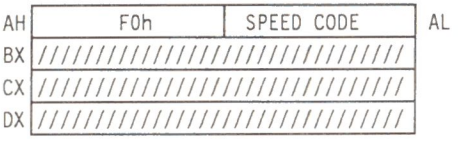
INPUT: AH = 12h



INT 16h, AH = F0h - SET CPU SPEED (8-MHZ SYSTEM)

INT 16h, AH = F0h, changes the value of the 8042 output port to specify the current CPU speed.

INPUT:
AH = F0h
AL = 00h Set CPU/bus speed to 6 MHz (common)
= 01h Set CPU/bus speed to 8 MHz/6 MHz (FAST)
= 02h Set CPU/bus speed to 8 MHz/8 MHz (HIGH)
= 03h Toggle CPU speed between 6 MHz and the default CPU speed limit (HIGH or FAST)

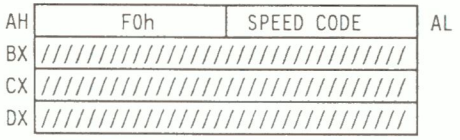


OUTPUT: None.

INT 16h, AH = F0h - SET CPU SPEED (12-MHZ SYSTEM)

INT 16h, AH = F0h, changes the value of the 8042 output port to specify the current CPU speed.

INPUT:
AH = F0h Set CPU speed
AL = 00h Reserved
= 01h Set CPU/bus speed to 8 MHz/8 MHz (FAST)
= 02h Set CPU/bus speed to 12 MHz/8 MHz (HIGH)
= 03h Toggle CPU speed between 8 MHz and the default CPU speed limit (HIGH or AUTO = upon CTRL + ALT + \)
= 08h Sets CPU speed to switch between 8 MHz and 12 MHz during diskette operations (AUTO)

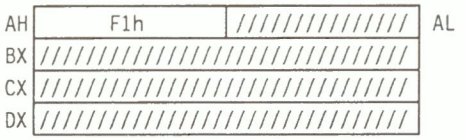


OUTPUT: None.

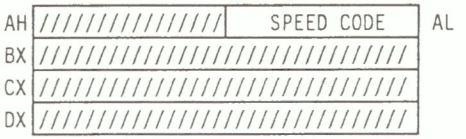
INT 16h, AH = F1h - READ CURRENT CPU SPEED (8-MHZ SYSTEM)

INT 16h, AH = F1h reads the 8042 keyboard controller input port values to determine the current CPU speed.

INPUT: AH = F1h



OUTPUT: AL = Speed Code (00h,01h,02h)

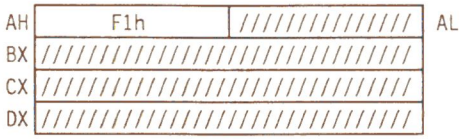


AL = 01h if CPU/bus speed is 6 MHz/6MHz (common)
02h if CPU/bus speed is 8 MHz/6 MHz (FAST)
= 08h if CPU/bus speed is 8 MHz/8 MHz (HIGH)

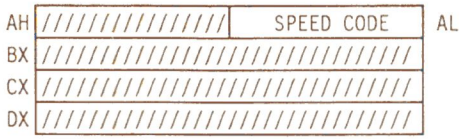
INT 16h, AH = F1h - READ CURRENT CPU SPEED (12 MHZ SYSTEM)

INT 16h, AH = F1h reads the 8042 keyboard controller input port values to determine the current CPU speed.

INPUT: AH = F1h



OUTPUT: AL = Speed Code (01h,02h,08h)

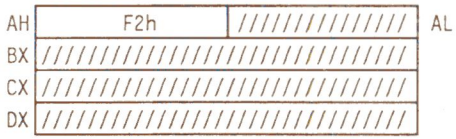


AL = XXh if CPU/bus speed is 8 MHz/8 MHz (FAST)
= XXh if CPU/bus speed is 12 MHz/8 MHz (HIGH)
= XXh if CPU/bus speed is AUTO

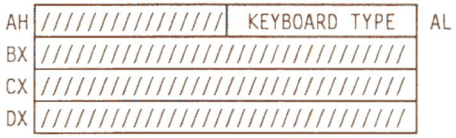
INT 16h, AH = F2h - DETERMINE ATTACHED KEYBOARD

INT 16h, AH = F2h determines whether a 9- or 11-bit keyboard is in use.

INPUT: AH = F2h



OUTPUT:
AL = 00h if 11-bit keyboard in use (standard)
= 01h if 9-bit keyboard in use



INT 1Bh - SW - CTRL + BREAK SERVICE

INT 1Bh is called from the ROM when the CTRL + BREAK keys are pressed. INT 1Bh is provided to allow MS-DOS and USER PROGRAMS a way to exit a program.

ROM ENTRY: Points to an interrupt Return.

ROM ACTION: Control returns to the calling program.

USE: The vector for this interrupt is normally used by the operating system. It can be changed to point to a user-supplied routine.

INPUT: None.

OUTPUT: None.

INT 09h - HW - IRQ1, KEYBOARD
- CPU - 80287 SEGMENT OVERRUN

INT 09h occurs each time a keyboard key is pressed or released.

INT 09h normally handles the keyboard hardware interrupts from IRQ1. However, if the system is operating in the Protected mode, INT 09h is issued by the 80286 when an 80287 Segment Overrun exception is detected.

Operating system software running in the Protected mode can readily relocate hardware interrupts IRQ0 through IRQ7 to another block of eight interrupt vectors to avoid conflict. (See INT 15h, AH = 89h.)

ROM ENTRY: Points to ROM Keyboard Interrupt handler.

ROM ACTION: The interrupt routine reads the key from the 8042 keyboard registers, encodes the key or takes special action if required, notifies the 8042 that the key has been read, clears the 8259A interrupt controller, and loads the encoded key into the keyboard buffer.

INPUT: Keyboard.

OUTPUT: Keyboard type-ahead buffer.

USE: The vector for this interrupt can be changed to select a user-supplied keyboard handler.

14.11 FIXED DISK DRIVE INTERRUPTS

The BIOS for fixed disks supports two fixed disk drives, Drive 1 (80h) and Drive 2 (81h). Use INT 13h, AH = 08h to determine their individual capacities, or use the parameter table pointed to by INT 41h and INT 46h. Do not use the fixed disk drive types stored in configuration memory to determine the capacities.

The fixed disk drive Wait and Post functions are supported via INT 15h. The fixed disk drive Wait function call is AH = 90h, AL = 00h. The function call for Post is AH = 91h, AL = 00h. Wait is performed to wait for a fixed disk drive interrupt. Post is performed when the fixed disk drive interrupt occurs.

If an error occurs on a fixed disk drive operation, reset (INT 13h, AH = 00h or 0Dh) the fixed disk drive system before retrying the operation. The fixed disk drive controller performs internal retries before returning an error.

When using the Read or Write functions, the MSB of the Drive Control Byte (at offset +08h) of the fixed disk drive parameter table at INT 41h or INT 46h can be set to 1 to disable the fixed disk drive controller internal-retry function.

To format a fixed disk drive with more than 8 heads, recalibrate (INT 13h, AH = 11h) Head 0, then format Heads 0 though 7. Next, recalibrate Head 8 and format Heads 8 through 15.

Table 14-36 lists the BIOS fixed disk drive interrupts. Table 14-37 lists the memory locations used.

Table 14-36. Fixed Disk Drive Interrupts

Interrupts Available	Type	Function
INT 13h	SW	Fixed Disk I/O
INT 76h	HW	IRQ14, Fixed Disk Drive Interrupt
INT 41h	PTR	Fixed Disk Drive 1 Parameter Table
INT 46h	PTR	Fixed Disk Drive 2 Parameter Table

Table 14-37. Memory Locations Used by Fixed Disk Drive Interrupts

Memory Location	Bytes	Function
0000:004C	4	INT 13h Vector
0000:0104	4	INT 41h Vector
0000:0118	4	INT 46h Vector
0000:01D8	4	INT 76h Vector
0040:0074	1	Fixed Disk Drive Status
0040:0075	1	Number of Fixed Disk Drives
0040:0076	1	Drive Control Byte
0040:0077	1	Reserved

Table 14-38 lists the error or status codes returned in the AH register by the various interrupts.

Table 14-38. Fixed Disk Drive Status Codes by AH Function

AH	Error Code																
Function	00h	01h	02h	04h	05h	07h	09h	0Ah	10h	11h	20h	40h	80h	AAh	BBh	CCh	FFh
00h	X	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
01h	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
02h	X	X	X	-	-	X	X	X	X	X	-	X	X	X	X	X	-
03h	X	X	X	X	-	-	X	X	-	-	X	-	X	X	X	X	X
04h	X	X	X	X	-	-	-	X	X	X	X	-	X	X	X	X	X
05h	X	X	X	X	-	-	X	X	-	-	X	-	X	X	X	X	X
08h	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
09h	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
0Ah	X	X	X	X	-	-	-	X	-	-	X	-	X	X	X	X	X
0Bh	X	X	X	X	-	-	-	X	-	-	X	-	X	X	X	X	X
0Ch	X	X	-	-	-	-	-	-	-	-	X	X	X	X	X	X	X
0Dh	X	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
10h	X	X	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
11h	X	X	-	-	-	-	-	-	-	-	-	-	X	X	X	X	X
14h	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15h	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Legend: x = Possible error codes returned by function.
- = Error code does not apply.

Table 14-39 lists the descriptions for the codes returned in the AH register for the various interrupts.

Table 14-39. Fixed Disk Drive Status Code Descriptions

AH	Meaning
00h	Successful Completion
01h	Bad Command
02h	Address Mark Not Found
04h	Requested Sector Not Found
05h	Reset Failed
07h	Drive Parameter Activity Failed
09h	Transfer Attempted Across 64K Boundary
0Ah	Bad Block Flag Detected
10h	Uncorrectable ECC Data Error
11h	ECC Corrected Data Error
20h	Controller Has Failed
40h	Seek Operation Failed
80h	Drive Failed To Respond
AAh	Drive Not Ready
BBh	Undefined Error Occurred
CCh	Write Fault Active
FFh	Sense Operation Failed

INT 13h - SW - FIXED DISK DRIVE I/O

INT 13h is called to perform all functions related to Fixed Disk Drive I/O.

ROM ENTRY: Points to Fixed Disk Drive I/O ROM entry point.

ROM ACTION: Upon entry, control is transferred to one of 16 routines (listed below) based on the function code in the AH register. Illegal function codes cause the routine to report a Bad Command error and return. Table 14-40 lists a function summary.

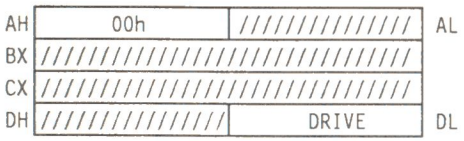
Table 14-40. Function Summary

AH	Function
00h	Reset Disk System
01h	Read Status of Last Operation
02h	Read Sectors
03h	Write Sectors
04h	Verify Sectors
05h	Format Track
08h	Get Current Drive Parameters
09h	Initialize Drive Parameters
0Ah	Read Long
0Bh	Write Long
0Ch	Seek Cylinder
0Dh	Alternate Disk Reset
10h	Test Drive Ready
11h	Recalibrate Drive
14h	Controller Diagnostic
15h	Read Drive Type

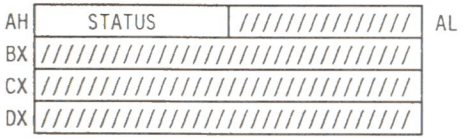
INT 13h, AH = 00h - RESET FIXED DISK DRIVE SYSTEM

INT 13h, AH = 00h resets the fixed disk drive system and fixed disk drive parameters. If two fixed disk drives are present, then the parameters for both fixed disk drives are set.

INPUT:
AH = 00h
DL = Drive Select (80h..81h)



OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = 05h (Reset Failed)

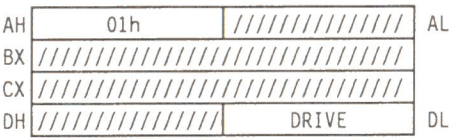


Reset should be done after a read, write, verify, or format error before retrying the operation.

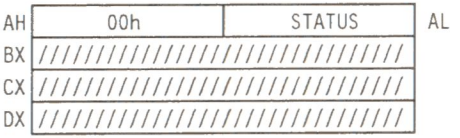
INT 13h, AH = 01h - SENSE STATUS OF LAST OPERATION

INT 13h, AH = 01h returns the status of the last fixed disk drive operation. The carry flag is not set if the last operation was in error.

INPUT:
AH = 01h
DL = Drive Select (80h..81h)



OUTPUT:
AH = 00h
AL = Status of last operation



INT 13h, AH = 02h - READ SECTORS

INT 13h, AH = 02h reads the specified number of sectors into the buffer pointed to by ES:BX.

INPUT:
AH = 02h
AL = Sector Count - Number of sectors to be read
ES:BX = Buffer Address
CH = Bits <7..0> of starting cylinder
CL = Bits <7..6> are bits <9..8> of starting cylinder
= Bits <5..0> are starting sector
DH = Starting Head
DL = Drive (80h..81h)

AH	02h	SECTOR COUNT	AL
BX	BUFFER OFFSET		
CH	CYLINDER	CYL/SECTOR	CL
DH	HEAD	DRIVE	DL

ES	BUFFER SEGMENT

OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error

AH	OP STATUS	//////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

The maximum number of sectors that can be read is 128 (80h) if the transfer address starts on a paragraph boundary. Otherwise, 127 sectors is the maximum.

A sector count of 00h implies 256 sectors.

INT 13h, AH = 03h - WRITE SECTORS

INT 13h, AH = 03h writes the specified number of sectors using the data from the buffer pointed to by ES:BX.

INPUT:
AH = 03h
AL = Sector Count - Sectors to be written by this operation.
ES:BX = Buffer Address
CH = Bits <7..0> of starting cylinder
CL = Bits <7..6> are bits <9..8> of starting cylinder
Bits <5..0> are starting sector
DH = Starting Head
DL = Drive Select (80h..81h)

AH	03h	SECTOR COUNT	AL
BX	BUFFER OFFSET		
CH	CYLINDER	CYL/SECTOR	CL
DH	HEAD	DRIVE	DL

ES	BUFFER SEGMENT

OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error

AH	OP STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

The maximum number of sectors that can be read is 128 (80h) if the transfer address starts on a paragraph boundary. Otherwise, 127 sectors is the maximum.

A sector count of 00h implies 256 sectors.

INT 13h, AH = 04h - VERIFY SECTORS

INT 13h, AH = 04h verifies sectors on the fixed disk drive. Sector verification checks the sector ID and other format information for parity errors and data integrity.

INPUT:
AH = 04h
AL = Sector Count - Number of sectors to verify
CH = Bits <7..0> of Starting Cylinder
CL = Bits <7..6> are bits <9..8> of Starting Cylinder
Bits <5..0> are Starting Sector
DH = Starting Head
DL = Drive Select (80h..81h)

AH	04h	SECTOR COUNT	AL
BX	////////////////////////////////		
CH	CYLINDER	CYL/SECTOR	CL
DH	HEAD	DRIVE	DL

OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error

AH	OP STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

INT 13h, AH = 05h - FORMAT TRACK

INT 13h, AH = 05h writes the sector and track ID information onto the tracks specified.

INPUT:
AH = 05h
ES:BX = Track Interleave Table Address
CH = Bits <7..0> of cylinder
CL = Bits <7..6> are bits <9..8> of cylinder
Bits <5..0> are not used
DH = Head
DL = Drive Select (80h..81h)

AH	05h	////////////////	AL
BX	TABLE OFFSET		
CH	CYLINDER	CYLINDER	CL
DH	HEAD	DRIVE	DL

ES	TABLE SEGMENT

OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error

AH	OP STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

INT 13h, AH = 08h - GET DRIVE PARAMETERS

INT 13h, AH = 08h returns the drive parameters for the selected fixed disk drive.

INPUT:
AH = 08h
DL = Drive Select (80h..81h)

AH	08h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DH	////////////////	DRIVE	DL

OUTPUT:
AH = 00h (Successful Completion)

CH = Bits <7..0> of max value for cylinder

CL = Bits <7..6> are bits <9..8> of cylinder

Bits <5..0> are the max value for the sector
DH = Max value for head
DL = Number of drives (0..2)

AH	00h	////////////////	AL
BX	////////////////////////////////		
CH	MAX CYLINDER	MAX CYL/MAX SEC	CL
DH	MAX HEAD	# OF DRIVES	DL

INT 13h, AH = 09h - INITIALIZE FIXED DISK DRIVE PARAMETERS

INT 13h, AH = 09h loads the fixed disk drive parameters into the fixed disk drive controller.

INT 41h points to the parameter table for fixed disk drive 1 (Drive Select = 80h). INT 46h points to the parameter table for fixed disk drive 2 (Drive Select = 81h).

INPUT:
AH = 09h
DL = Drive Select (80h..81h)

AH	09h	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DH	////////////////	DRIVE	DL

OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error

AH	OP STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

INT 13h, AH = 0Ah - READ LONG

INT 13h, AH = 0Ah reads the specified sectors of data, plus the 4 Error Checking and Correcting code (ECC) bytes into the buffer pointed to by ES:BX.

INPUT:
AH = 0Ah

AL = Sector Count - Number of sectors to be read
ES:BX = Buffer Address
CH = Bits <7..0> of Starting Cylinder
CL = Bits <7..6> are bits <9..8> of Starting Cylinder
Bits <5..0> Starting Sector
DH = Starting Head
DL = Drive Select (80h..81h)

AH	0Ah	SECTOR COUNT	AL
BX	BUFFER OFFSET		
CH	CYLINDER	CYL/SECTOR	CL
DH	HEAD	DRIVE	DL

ES	BUFFER SEGMENT

OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error

AH	OP STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

The maximum number of sectors that can be read is 127 (7Fh).

A sector count of 00h implies 256 sectors.

INT 13h, AH = 0Bh - WRITE LONG

INT 13h, AH = 0Bh writes the specified number of sectors of data, plus the 4 Error Checking and Correcting code (ECC) bytes. ES:BX points to the starting address for the data to be written.

INPUT:
AH = 0Bh
AL = Sector Count - Number of sectors to write
ES:BX = Buffer Address
CH = Bits <7..0> of Starting Cylinder
CL = Bits <7..6> are bits <9..8> of Starting Cylinder
Bits <5..0> Starting Sector
DH = Starting Head
DL = Drive Select (80h..81h)

AH	0Bh	SECTOR COUNT	AL
BX	BUFFER OFFSET		
CH	CYLINDER	CYL/SECTOR	CL
DH	HEAD	DRIVE	DL

ES	BUFFER SEGMENT

OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error

AH	OP STATUS	///////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

The maximum number of sectors that can be read is 127 (7Fh) .

A sector count of 00h implies 256 sectors.

INT 13h, AH = 0Ch - SEEK CYLINDER

INT 13h, AH = 0Ch instructs a fixed disk drive to step the drive head to the specified cylinder.

INPUT:
AH = 0Ch
CH = Bits <7..0> of Target Cylinder

CL = Bits <7..6> are bits <9..8> of Target Cylinder

Bits <5..0> are not used
DH = Not used
DL = Drive Select (80h..81h)

AH	0Ch	////////////////	AL
BX	////////////////////////////////		
CH	CYLINDER	CYLINDER	CL
DH	////////////////	DRIVE	DL

OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error
AL = 00h

AH	OP STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

INT 13h, AH = 0Dh - ALTERNATE DISK RESET

INT 13h, AH = 0Dh resets the fixed disk drive controller. This interrupt has the same results as INT 13h, AH = 00h.

INPUT:
AH = 0Dh
DL = Drive Select (80h..81h)

AH	0Dh	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DH	////////////////	DRIVE	DL

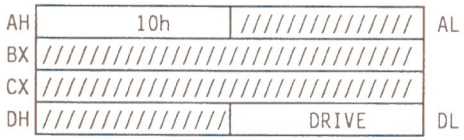
OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error

AH	OP STATUS	////////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

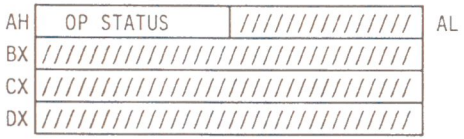
INT 13h, AH = 10h - TEST DRIVE READY-

INT 13h, AH = 10h tests the status of the DRIVE READY- signal on the selected fixed disk drive.

INPUT:
AH = 10h
DL = Drive Select (80h..81h)



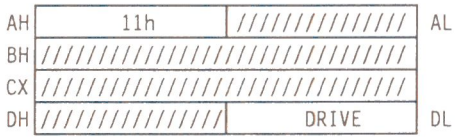
OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error



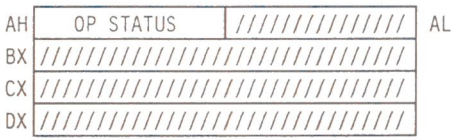
INT 13h, AH = 11h - RECALIBRATE DRIVE

INT 13h, AH = 11h instructs the specified fixed disk drive to recalibrate. The fixed disk drive recalibrates by seeking track 000.

INPUT:
AH = 11h
DL = Drive Select (80h..81h)



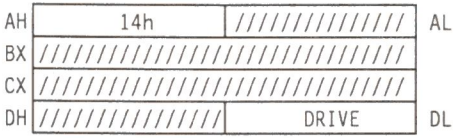
OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error



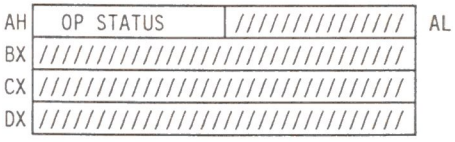
INT 13h, AH = 14h - CONTROLLER DIAGNOSTIC

INT 13h, AH = 14h instructs the fixed disk drive controller to run a self-test (diagnostic).

INPUT:
AH = 14h
DL = Drive Select (80h..81h)



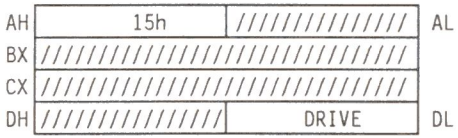
OUTPUT:
If CF = 0, AH = 00h (Successful Completion)
If CF = 1, AH = Status, Operation Error



INT 13h, AH = 15h - GET TYPE OF DRIVE

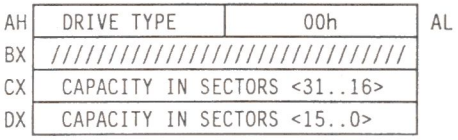
INT 13h, AH = 15h returns a drive-type code for the drive specified.

INPUT:
AH = 15h
DL = Drive Select (00h..02h or 80h..81h)



OUTPUT:
AH = Type of Drive
- 00h = Drive not present
- 01h = Diskette drive without change line
- 02h = Diskette drive with change line
- 03h = Fixed disk drive

AL = 00h
CX:DX = If drive type = 03h, CX:DX is the capacity of the drive, in 512-byte sectors. Otherwise, CX:DX are unchanged.



INT 76h - HW - IRQ14, FIXED DISK INTERRUPT

INT 76h interrupt occurs at the completion of a fixed disk drive operation. The vector for this interrupt points to the entry point of the Fixed Disk Drive Operation Complete routine. The source of this interrupt is the fixed disk drive controller hardware.

ROM ENTRY: Points to ROM Fixed Disk Drive Interrupt handler.

ROM ACTION: Calls made to the ROM using INT 13h for fixed disk I/O are normally suspended internally until INT 76h occurs, signifying completion.

INPUT: None.

OUTPUT: None.

USE: The vector for this interrupt can be changed to intercept fixed disk I/O operations for special real-time operating system requirements, such as concurrent diskette drive I/O.

INT 41h - PTR - FIXED DISK DRIVE 1 PARAMETER TABLE

The vector for INT 41h points to a fixed disk drive parameter table (described below) which contains drive-dependent information used to program the fixed disk drive controller.

Parameter	Offset
MAX CYLINDERS	+00h
MAX HEADS	+02h
////////////////////////////	+03h
////////////////////////////	+04h
WRITE PRECOMPENSATION CYLINDER	+05h
MAX ECC BURST	+07h
DRIVE CONTROL	+08h
////////////////////////////	+09h
////////////////////////////	+0Ah
////////////////////////////	+0Bh
LANDING ZONE CYLINDER	+0Ch
SECTORS/TRACK	+0Eh
////////////////////////////	+0Fh

Drive Control

BIT

76543210

- 000 (Reserved)
- 1 = More than 8 heads
- 00 (Reserved)
- Retries
  - 00 = Enabled
  - 11 = Disabled

INT 46h - PTR - FIXED DISK DRIVE 2 PARAMETER TABLE

The vector for INT 46h points to a fixed disk drive parameter table (described below) that contains drive-dependent information used to program the fixed disk drive controller.

Parameter	Offset
MAX CYLINDERS	+00h
MAX HEADS	+02h
////////////////////////////////	+03h
////////////////////////////////	+04h
WRITE PRECOMPENSATION CYLINDER	+05h
MAX ECC BURST	+07h
DRIVE CONTROL	+08h
////////////////////////////////	+09h
////////////////////////////////	+0Ah
////////////////////////////////	+0Bh
LANDING ZONE CYLINDER	+0Ch
SECTORS/TRACK	+0Eh
////////////////////////////////	+0Fh

Drive Control

BIT

76543210

- 000 (Reserved)
- 1 = More than 8 heads
- 00 (Reserved)
- Retries
  - 00 = Enabled
  - 11 = Disabled

The Max ECC Burst byte is always 00h. The Drive Control byte value is 00h for a fixed disk drive with 8 heads or less. The Drive Control byte value is 08h for a fixed disk drive with 9 heads or more.

Table 14-41 lists the typical values for the fixed disk drive parameter table. Drive types 1, 2, 6, and 12 are used for 10-, 20-, 30-, and 70-megabyte fixed disk drive types, respectively. Drive types 17 and 2 are used for 40- and integrated 20-megabyte fixed disk drive types, respectively. A value of "NO" for the Write Precompensation Cylinder column means that no write precompensation is used for that fixed disk drive. The values (number of heads, cylinders, and so on) for the other drive types are subject to change.

Table 14-41. Fixed Disk Drive Parameter Table

Drive Type	Cylinders	Max Heads	Write Precomp. Cyl.	Landing Zone Cyl.	Sectors/ Track	Capacity (MB)
1	306	4	128	305	17	10.65
2	615	4	128	638	17	21.41
3	615	6	128	615	17	32.12
4	1024	8	512	1023	17	71.30
5	940	6	512	939	17	49.09
6	697	5	128	696	17	30.33
7	462	8	256	511	17	32.17
8	925	5	128	924	17	40.26
9	900	15	NO	899	17	117.50
10	980	5	NO	980	17	42.65
11	925	7	128	924	17	56.36
12	925	9	128	924	17	72.46
13	612	8	256	611	17	42.61
14	980	4	128	980	17	34.12
15	RESERVED - SET TO ALL ZEROS					
16	612	4	0	612	17	21.31
17	980	5	128	980	17	42.65
18	966	6	128	966	17	50.45
19	1023	8	NO	1023	17	71.23
20	733	5	256	732	17	31.90
21	733	7	256	732	17	44.66
22	805	6	NO	805	17	42.04
23	924	8	NO	924	17	64.34
24	966	14	NO	966	17	117.71
25	966	16	NO	966	17	134.53
26	1023	14	NO	1023	17	124.66
27	966	10	NO	966	17	84.08
28	748	16	NO	748	17	104.17
29	805	6	NO	805	26	64.30
30	615	4	128	615	25	31.49
31	615	8	128	615	25	62.98
32	905	9	128	905	25	104.26
33	748	8	NO	748	34	104.77
34	966	7	NO	966	34	117.71
35	966	8	NO	966	34	134.53
36	966	9	NO	966	34	151.35
37	966	5	NO	966	34	84.08
38	611	16	NO	611	63	315.33
39	1023	11	NO	1023	33	190.13
40	1023	15	NO	1023	34	267.13
41	1023	15	NO	1023	33	259.27
42	1023	16	NO	1023	63	527.97
43	805	4	NO	805	26	42.86
44	805	2	NO	805	26	21.43
45	748	8	NO	748	33	101.11
46	748	6	NO	748	33	75.83
47	966	5	128	966	25	61.82

Note: A "NO" in the Write Precompensation Cylinder column means that no write precompensation is used for that fixed disk drive.

14.12 VIDEO INTERRUPTS

Information in this section applies when the system includes no video board with option ROM. If included, many INT 10h functions are extended or replaced. (See BIOS technical information for the specific video option for details.)

The BIOS video interrupts provide access to the video display controller using software interrupt INT 10h. Many functions are provided, including:

- Initializing the display in one of several formats
- Reading from or writing to the screen memory
- Scrolling a window on the display.

Two other interrupts, INT 1Dh and INT 1Fh, are provided for altering the CRT controller parameters and providing an extension to the graphics mode dot table, respectively.

Two video display controllers are supported: a color/graphics controller that uses memory addresses beginning at 0B8000h, and/or a monochrome/text video display controller that uses memory addresses beginning at 0B0000h. However, BIOS has the capability of initializing and supporting only one active display controller at a time.

During power-on, the BIOS checks the configuration memory, byte (0040:0010), bits <5..4> to determine the type of display used initially. The initial display mode can be either 1) 40 x 25 color/graphics or 80 x 25 character text mode or 2) the monochrome/text display in 80 x 25 character format.

Use the Set Video Mode command (INT 10h, AH = 00h) to initialize the video display controller.

Whether to use BIOS or to directly access the screen memory depends on how much software portability or application performance is needed.

Updating the screen memory of a COMPAQ video display controller or a monochrome/text display controller requires no waiting for display retrace or screen blanking periods. However, most color/graphics display controllers require screen memory to be updated (or read) only when the display is inactive. This requirement prevents display "snow" from appearing on the screen during access.

Table 14-42 lists the BIOS video interrupts. Table 14-43 lists the memory locations used.

Table 14-42. Video Interrupts

Interrupt	Type	Function
INT 10h	SW	Video I/O
INT 1Dh	PTR	Video Parameter Table
INT 1Fh	PTR	Dot Table

Table 14-43. Memory Locations Used by Video Interrupts

Memory Location	Bytes	Function
0000:0040	4	INT 10h Vector
0000:0074	4	INT 1Dh Vector
0000:007C	4	INT 1Fh Vector
0040:0049	1	Current Video Mode
0040:004A	2	Number of Columns on Screen
0040:004C	2	Length of Screen Memory in Bytes
0040:004E	2	Start of Screen Memory
0040:0050	16	Cursor Save Area for Each Page (8 entries)
0040:0060	2	Cursor Mode (start and end scanline)
0040:0062	1	Current Page Being Displayed
0040:0063	2	Base Address of Active Video Interface Board
0040:0065	1	Current Mode
0040:0066	1	Current Color

INT 10h - SW - VIDEO I/O

INT 10h performs all functions related to the video display.

ROM ENTRY: Points to video I/O ROM entry point.

ROM ACTION: Upon entry, control is transferred to one of 17 routines (listed below) based on the function code in register AH. Illegal function codes cause control to simply return.

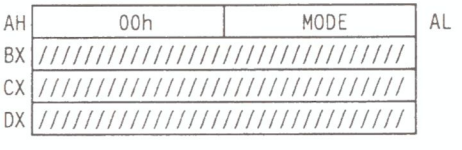
Function Summary

AH	Action
00h	Set Video Mode
01h	Set Cursor Type
02h	Set Cursor Position
03h	Read Cursor Position
04h	Read Lightpen Position
05h	Select Active Display Page
06h	Scroll Active Page Up
07h	Scroll Active Page Down
08h	Read Attribute/Character at Cursor Position
09h	Write Attribute/Character at Cursor Position
0Ah	Write Character Only at Cursor Position
0Bh	Set Color Palette
0Ch	Write Pixel
0Dh	Read Pixel
0Eh	Write TTY
0Fh	Read Current Video State
13h	Write String
14h	Load Character Generator
BFh	Video BIOS Extensions

INT 10h, AH = 00h - SET VIDEO MODE

INT 10h, AH = 00h loads the video display controller registers with values for the specified video mode.

INPUT:
AH = 00h
AL = Mode (0..7)
- 0 = 40 x 25 B&W
- 1 = 40 x 25 Color
- 2 = 80 x 25 B&W
- 3 = 80 x 25 Color (standard)
- 4 = 320 x 200 Color
- 5 = 320 x 200 B&W
- 6 = 640 x 200 B&W
- 7 = 80 x 25 Monochrome (Not compatible with COMPAQ monitors)



OUTPUT: None.

When the primary display (as specified in the System Configuration Word) is monochrome, attempts to change from video Mode 00 to 6 are not performed. The screen is cleared. When the primary display is color/graphics, attempts to change to Mode 7 are not performed.

Modes 0 and 1 use 8 x 8 dot-character cells from the character ROM on the video display controller.

Modes 2 and 3 use the 9 x 14 dot-character cells from the character ROM on the video display controller. Alternately, the 8 x 8 dot mode can be chosen by pressing the CTRL + ALT + < (less-than) keys simultaneously.

Modes 4, 5, and 6 display the 8 x 8 dot cell characters using ROM firmware to read a look-up table in the system ROM and write the pixels on the screen.

Mode 7 directs video I/O to an optional monochrome display controller board (not available from Compaq).

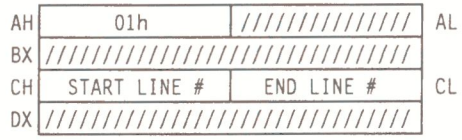
When switching between high-definition (Modes 2 or 3) and any other mode, the system provides a 500-ms delay that allows the COMPAQ Dual-Mode Monitor to change frequencies.

Color burst on the composite-video output is not enabled in B&W modes; otherwise B&W and color operate in an identical manner.

INT 10h, AH = 01h - SET CURSOR TYPE

INT 10h, AH = 01h specifies the scan lines used for the cursor.

INPUT:
AH = 01h
CH = Start Line Number for Cursor in Bits <4..0>
CL = End Line Number for Cursor in Bits <4..0>



OUTPUT: None.

For 9 x 14-pixel displays, the BIOS code multiplies the incoming start and stop lines by 14/8 and rounds the result to the nearest integer to map it to a cell that is 14 scan lines high instead of 8.

Table 14-44 illustrates the adjustment.

Table 14-44. Cursor Adjustment

In	x 14/8	Out(Scan Line)
0	0.00	0
1	1.75	2
2	3.50	4
3	5.25	5
4	7.00	7
5	8.75	9
6	10.50	11
7	12.25	12
8	(See Note)	8
:		:
31		31

Note: The Set Cursor Type function takes special action if the current Mode is 2 or 3 (80 x 25) and the high-definition (9 x 14 dot cell) character set is in use.

When the start or stop line exceeds 7, both values are passed unaltered to the CRT controller.

INT 10h, AH = 02h - SET CURSOR POSITION

INT 10h, AH = 02h places the cursor at the specified screen location.

INPUT:
AH = 02h
BH = Page Number (0..7) for Modes 0, 1;
(0..3) for Modes 2, 3;
(0) for Modes 4..7
DH = Row (0..24)
DL = Column (0..39) for Modes 0, 1;
(0..79) for Modes 2, 3, 7

AH	02h	////////////////	AL
BH	PAGE NUMBER	////////////////	BL
CX	////////////////////////////////		
DH	ROW	COLUMN	DL

OUTPUT: None.

INT 10h, AH = 03h - READ CURSOR POSITION

INT 10h, AH = 03h returns the current horizontal and vertical position of the cursor.

INPUT:
AH = 03h
BH = Page Number (0..7) for Modes 0, 1;
(0..3) for Modes 2, 3;
(0) for Modes 4..7

AH	03h	////////////////	AL
BH	PAGE NUMBER	////////////////	BL
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUT:
CH = Start Line Number For Cursor in Bits <4..0>
CL = End Line Number for Cursor in Bits <4..0>
DH = Row
DL = Column

AX	////////////////////////////////		
BX	////////////////////////////////		
CH	START LINE #	END LINE #	CL
DH	ROW	COLUMN	DL

The Read Cursor Position function takes special action if the current mode is Mode 2 or 3 (80 x 25) and the high-definition (9 x 14 dot cell) character set is in use. Since application programs expect a number in the range (0..7), and the physical line number is in the range (0..13), the BIOS first multiplies the number by 8/14 and rounds the result to the nearest integer.

Table 14-45 shows the high-resolution display mapping.

Table 14-45. High-Resolution Display Mapping

In (Scan Line)	x 8/14	Out (Returned)
0	0.00	0
1	0.57	1
2	1.14	1
3	1.71	2
4	2.29	2
5	2.86	3
6	3.43	3
7	4.00	4
8	4.57	5
9	5.14	5
10	5.71	6
11	6.29	6
12	6.86	7
13	7.43	7

INT 10h, AH = 04h - READ LIGHTPEN POSITION

INT 10h, AH = 04h reads the contents of the lightpen register on the video display controller. The lightpen register specifies the pixel position of the lightpen on the screen.

INPUT:
AH = 04h

AH	04h	//////////////	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUT:
AH = 0 Lightpen Switch Not Triggered
= 1 Valid Lightpen in Registers
BX = Pixel Column (0..319) for Modes 4, 5;
(0..639) for Mode 6
CH = Raster Line (0..199)
DH = Row of Character Lightpen is on
DL = Column of Character Lightpen is on

AH	PEN VALID	//////////////	AL
BX	PIXEL COLUMN		
CH	RASTER LINE	//////////////	CL
DH	CHAR ROW	CHAR COLUMN	DL

The lightpen resolution is equivalent to the character-grid layout of the screen.

INT 10h, AH = 05h - SELECT ACTIVE DISPLAY PAGE

INT 10h, AH = 05h specifies the active display page.

INPUT:
AH = 05h
AL = New Page Value (0..7) for Modes 0, 1;
(0..3) for Modes 2, 3;
(0) for Mode 7

AH	05h	NEW PAGE VALUE	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

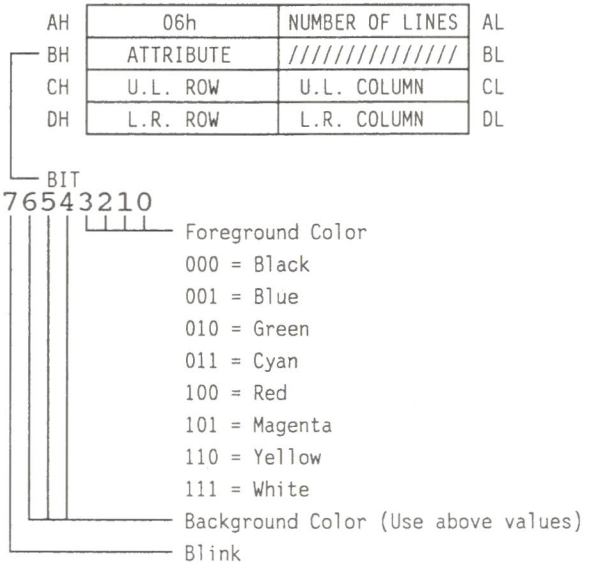
OUTPUT: None.

INT 10h, AH = 05h is not valid for the graphics display modes.

INT 10h, AH = 06h - SCROLL ACTIVE PAGE UP

INT 10h, AH = 06h scrolls an arbitrary window in the display up by the specified number of lines.

INPUT:
AH = 06h
AL = Number of Lines to Scroll (0..25)
AL = 0 means Blank Entire Window
BH = Attribute Used on Blank Lines (00h..FFh)
CH = Scroll Row - Upper-left Corner (0..DH)
CL = Scroll Column - Upper-left Corner (0..DL)
DH = Scroll Row - Lower-right Corner (CH..24)
DL = Scroll Column - Lower-right Corner
(CL..39) for Modes 0, 1;
(CL..79) for Modes 2, 3, 7



OUTPUT: None.

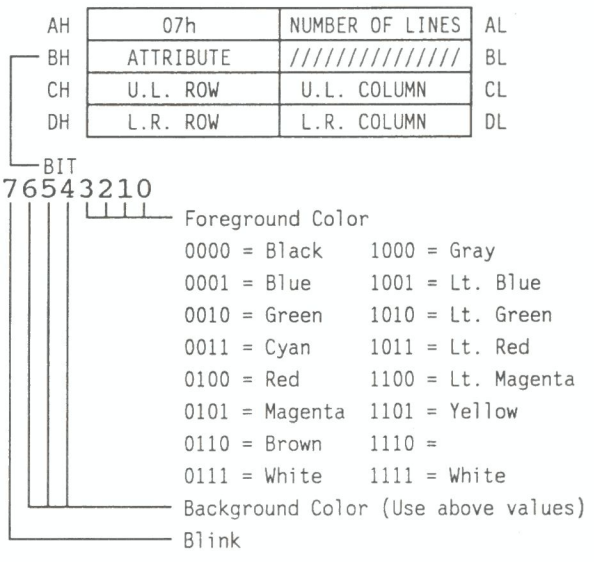
The input lines are blanked at the bottom of the window.

The normal value for the attribute byte is 07h.

INT 10h, AH = 07h - SCROLL ACTIVE PAGE DOWN

INT 10h, AH = 07h scrolls down an arbitrary window in the display by the specified number of lines.

INPUT:
AH = 07h
AL = Number of lines to scroll (0..25)
BH = Attribute used on blank lines (00h..FFh)
CH = Scroll row - upper-left corner (0..DH)
CL = Scroll column - upper-left corner (0..DL)
DH = Scroll row - lower-right corner (CH..24)
DL = Scroll column - lower-right corner
(CL..39) for Modes 0, 1;
(CL..79) for Modes 2, 3, 7



OUTPUT: None.

The input lines are blanked at the top of the window. The normal value for attribute byte is 07h.

INT 10h, AH = 08h - READ ATTRIBUTE/CHARACTER AT CURSOR POSITION

INT 10h, AH = 08h returns the ASCII code and attribute byte for the character at the specified screen position.

INPUT:
AH = 08h
BH = Display page in the text modes only
(0..7) for Modes 0, 1;
(0..3) for Modes 2, 3;
(0) for Modes 4, 5, 6, 7.

AH	08h	////////////////	AL
BH	DISPLAY PAGE	////////////////	BL
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUT:
AH = Attribute of Character Read
AL = Character Read

AH	ATTRIBUTE	CHAR READ	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

For the Read- and Write-Character functions while in the graphics mode, the characters are formed from a character-dot image in the system ROM. Only the first 128 characters are in the ROM. INT 1Fh points to a user-supplied table that contains the dot patterns for the second 128 characters.

The maximum character count is limited in the text modes to the end of the display page.

For Modes 4, 5, and 6 (graphics modes), a space can be written with either a 00h or 20h, but only a 00h is read back. Also, the attribute returned in AH is not valid for these modes.

The replication factor contained in register CX produces valid results only for characters on the same row in graphics Modes 4, 5, or 6.

INT 10h, AH = 09h - WRITE ATTRIBUTE/CHARACTER AT CURSOR POSITION

INT 10h, AH = 09h writes the ASCII code and attribute byte for the character at the specified screen position.

INPUT:
AH = 09h
AL = Character to Write (00h..FFh)
BH = Display Page in Text Modes Only
(0..7) for Modes 0, 1;
(0..3) for Modes 2, 3;
(0) for Modes 4, 5, 6, 7
BL = Attribute of Character to Write
If bit <7> of BL = 1, then the color value is XORed with the current contents of the character
CX = Count of Characters to Write
(1..1024) for Modes 0, 1;
(1..2048) for Modes 2, 3, 7;
(1..40) for Modes 4, 5;
(1..80) for Mode 6

AH	09h	CHARACTER	AL
BH	DISPLAY PAGE	ATTRIBUTE	BL
CX	COUNT OF CHARACTERS TO WRITE		
DX	////////////////////////////////		

OUTPUT: None.

INT 10h, AH = 0Ah - WRITE CHARACTER AT CURSOR POSITION

INT 10h, AH = 0Ah writes the ASCII code to the specified cursor position.

INPUT:
AH = 0Ah
AL = Character to Write
BH = Display Page in Text Modes Only
(0..7) for Modes 0, 1;
(0..3) for Modes 2, 3;
(0) for Modes 4, 5, 6, 7
BL = Attribute byte (Graphics mode only)
CX = Count of Characters to Write
(1..1024) for Modes 0, 1;
(1..2048) for Modes 2, 3, 7;
(1..40) for Modes 4, 5;
(1..80) for Mode 6

AH	0Ah	CHARACTER	AL
BH	DISPLAY PAGE	ATTRIBUTE	BL
CX	COUNT OF CHARACTERS TO WRITE		
DX	////////////////////////////////		

OUTPUT: None.

INT 10h, AH = 0Bh - SET COLOR PALETTE

INT 10h, AH = 0Bh specifies the color generated by the color palette for a color ID.

INPUT:
AH = 0Bh
BH = Palette Color ID Being Set (0..127)
BL = Color Value to be used with that Color ID

This interrupt has meaning only for Modes 4, 5
Color ID = 0 selects the background color (0..15).
Color ID = 1 selects the palette to be used.

AH	0Bh	///////////////	AL
BH	COLOR ID	COLOR VALUE	BL
CX	////////////////////////////////		
DX	////////////////////////////////		

Table 14-46 lists the color values that result.

Table 14-46. Color Palette Color Values

Value	Color	Value	Color
0	Black	8	Gray
1	Blue	9	Light blue
2	Green	10	Light green
3	Cyan	11	Light cyan
4	Red	12	Light red
5	Magenta	13	Light magenta
6	Brown	14	Yellow
7	White	15	White

OUTPUT: None.

INT 10h, AH = 0Ch - WRITE PIXEL

INT 10h, AH = 0Ch specifies the color of a pixel at the specified position.

INPUT:
AH = 0Ch
AL = Color Value
(0..3) or (80h..83h) for Modes 4, 5;
(0..1) or (80h..81h) for Mode 6 if bit 7 of AL is set to 1, then the color value is XORed with the current contents of the dot
CX = Column Number
(0..319) for Modes 4, 5;
(0..639) for Mode 6
DX = Row Number (0..199)

AH	0Ch	COLOR VALUE	AL
BX	////////////////////////////////		
CX	COLUMN NUMBER		
DX	ROW NUMBER		

Table 14-47 lists the color values and the resulting colors.

Table 14-47. Pixel Color Values

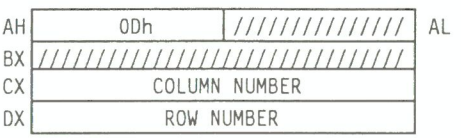
Value	Color Set	Color
0	Standard	Background
1	Standard	Green
2	Standard	Red
3	Standard	Brown
0	Alternate	Background
1	Alternate	Cyan
2	Alternate	Magenta
3	Alternate	White

OUTPUT: None.

INT 10h, AH = 0Dh - READ PIXEL

INT 10h, AH = 0Dh returns the color value for the specified pixel.

INPUT:
AH = 0Dh
CX = Column Number
(0..319) for Modes 4, 5;
(0..639) for Mode 6
DX = Row Number (0..199)



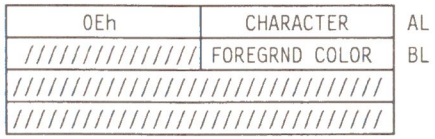
OUTPUT:
AL = The color value for the pixel read
(0..3) for Modes 4, 5
(0..1) for Mode 6

This function has significance only for graphics Modes 4, 5, and 6.

INT 10h, AH = 0Eh - WRITE TTY

INT 10h, AH = 0Eh writes characters to the screen as though the screen were a TTY receiving device. Only four ASCII codes are interpreted as standard TTY codes. The four ASCII codes are BEL, BS, LF, and CR. Characters are displayed for all other codes.

INPUT:
AH = 0Eh
AL = Character to Write
BL = Foreground Color in Graphics Mode
(0..3) for Modes 4, 5;
(0..1) for Mode 6



OUTPUT: None.

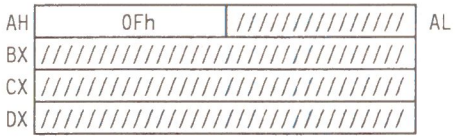
The screen width is controlled by the previously set mode.

The display page used is the active display page.

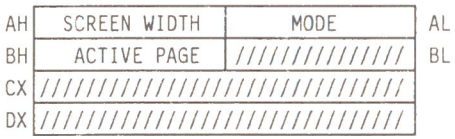
INT 10h, AH = 0Fh - READ VIDEO STATE

INT 10h, AH = 0Fh returns the current screen width, display mode, and active display page.

INPUT: AH = 0Fh



OUTPUT:
AH = Number of character columns on screen (40 or 80)
AL = Mode set (0..7)
BH = Active display page (0..7)



INT 10h, AH = 13h - WRITE STRING

INT 10h, AH = 13h writes a character string to the screen, starting at the specified position.

INPUT: AH = 13h
AL = Format code (0..3)
AL = 0, the string format is {char, char, ...,char} and the cursor IS NOT moved
AL = 1, the format of string is {char, char, ...,char} and the cursor IS moved
AL = 2, the format of string is {char, attr, ...,char, attr} the cursor IS NOT moved
AL = 3, format of string is {char, attr, ...,char,attr} and the cursor IS moved
BH = Display page (0..7)
BL = Attribute
CX = Length of string
DX = Cursor position to write string
DH = Row (0..24)
DL = Column (0..39, Modes 0,1,4,5)
(0..79, Modes 2,3,6,7)
ES:BP = Pointer to string

AH	13h	FORMAT CODE	AL
BH	DISPLAY PAGE	ATTRIBUTE	BL
CX	STRING LENGTH		
DH	ROW	COLUMN	DL

BP	STRING OFFSET

ES	STRING SEGMENT

OUTPUT: None.

Imbedded carriage control characters CR, LF, BS, and BEL do not have an associated attribute byte for AL = 2 or 3; the next character immediately follows.

The video Write String function always scrolls the active page even when writing to pages other than the active page. This occurs because a Write TTY is used with an LF to perform the scroll. On 80286 products (and the COMPAQ Enhanced Color Graphics Board BIOS), the Write TTY function ignores the page specified in BH and always writes to the active page. Carriage control characters CR, LF, and BS are also written using Write TTY and can cause a change in cursor position on the active page.

INT 10h, AH = BFh - VIDEO BIOS EXTENSIONS

Function BFh adds extensions to the video BIOS needed for sensing or altering the hardware environment.

INPUTS:
AH = BFh
AL = Sub-function
- 00h = Switch to External Monitor
- 01h = Switch to Internal Monitor
- 02h = [Reserved]
- 03h = [Reserved]
- 04h = Switch Monitor Delay
- 05h..FFh = [Reserved]

AH	BFh	SUB-FUNCTION	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

INT 10h, AH = BFh, AL = 00h - SWITCH TO EXTERNAL MONITOR

This interrupt directs the BIOS to switch to the external monitor. If the monitor is not present, or cannot support the format, then nothing happens and control is returned to the caller. If the COMPAQ Dual-Mode Monitor is connected it goes to the low-scan (200 lines) mode.

INPUTS:
AH = BFh
AL = 00h

AH	BFh	00h	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUTS: None

INT 10h, AH = BFh, AL = 01h - SWITCH TO INTERNAL MONITOR

This interrupt directs the BIOS to switch to the internal mode. If the monitor is not present or cannot support the format, then nothing happens and control is returned to the caller. If a COMPAQ Dual-Mode Monitor is connected, it goes to the high-scan (350 lines) mode.

INPUTS:
AH = BFh
AL = 01h

AH	BFh	01h	AL
BX	////////////////////////////////		
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUTS: None

INT 10h, AH = BFh, AL = 04h - SWITCH MONITOR DELAY

This interrupt enables or disables the 500-ms delay required for the COMPAQ Dual-Mode monitor (DSM). The delay allows the monitor time to settle with video off after it changes from low-scan to high-scan, or vice-versa. This call has no effect on enhanced color graphics (EGA) monitors.

INPUTS:
AH = BFh
AL = 04h

AH	BFh	04h	AL
BH	////////////////	ON/OFF	BL
CX	////////////////////////////////		
DX	////////////////////////////////		

OUTPUTS:
BL = 0 Delay ON
BL = 1 Delay OFF

INT 1Dh - PTR - PARAMETER TABLE

INT 1Dh points to a table of parameters that initializes the 6845 CRT controller after an INT 10h Set Video Mode command is issued.

ROM ENTRY: Points to ROM Default Video Init Parameter Table.

ROM ACTION: Not applicable.

INPUT: None.

OUTPUT: None.

USE: INT 1Dh can be used to supply a substitute parameter table for different CRT controller operating conditions. For example, the horizontal-sync position can be changed to compensate for certain monitors.

The vector at 0000:0074 for INT 1Dh can be changed to point to a user-supplied table consisting of four 16-byte entries.

The following chart shows the format of the video mode parameter table.

	Offset
40x25 Table Modes 00h, 01h	+00h
80x25 Table Modes 02h, 03h	+10h
Graphics Table Modes 04h, 05h, 06h	+20h
Monochrome Table Mode 07h	+30h

ROM actually contains two video mode parameter tables to accommodate switching between 9 x 14 dot cells and 8 x 8 dot cells (for External Color RGB Monitors) in the 80 x 25 character mode. Switching the parameter tables is accomplished by calls to INT 10h, AH = BFh, AL = 00h, and AL = 01h.

INT 10h, AH = BFh, AL = 01h selects the 80 x 25 low-scan display using 8 x 8 dot cell characters and the INT10h, AH = BFh, AL = 00h selects the high-scan display using 9 x 14 dot cells. Only the table for the 80 x 25 entry differs between 8 x 8 mode and 9 x 14 modes.

Table 14-48 lists the typical values for various video modes.

Table 14-48. Typical Parameters for Various Video Modes

	Defaults (Decimal)							
	High-Resolution				Low-Resolution			
Parameters	40 x 25	80 x 25	Graphics	Mono.	40 x 25	80x25	Graphics	Mono.
Horizontal total in characters	56	113	56	97	56	113	56	97
Horizontal display in characters	40	80	40	80	40	80	40	80
Horizontal sync position in characters	45	90	45	82	45	90	45	82
Horizontal sync width in characters	10	10	10	14	10	10	10	15
Vertical total in character rows	31	25	127	25	31	31	127	25
Vertical total adjust in scan	6	6	6	6	6	6	6	6
Vertical display in character rows	25	25	100	25	25	25	100	25
Vertical sync position in character rows	28	25	112	25	28	28	112	25
Interlace mode	2	2	2	2	2	2	2	2
Max scan line address	7	1	1	13	7	7	1	13
Cursor start scan	6	11	6	11	6	6	6	11
Cursor end scan	7	12	7	12	7	7	7	12
Start address (H)	0	0	0	0	0	0	0	0
Start address (L)	0	0	0	0	0	0	0	0
Cursor address (H)	0	0	0	0	0	0	0	0
Cursor address (L)	0	0	0	0	0	0	0	0

INT 1Fh - PTR - DOT TABLE

INT 1Fh points to a user-supplied dot table used to generate and read 8 x 8 dot graphics characters in Modes 4, 5, and 6. This table is needed only for those characters within the range of 80h..FFh.

ROM ENTRY: 0000:0000

ROM ACTION: INT 1Fh is used exclusively by the INT 05h Print Screen and INT 10h Video I/O routines, and then only in the graphics modes for the upper-128 character set.

INPUT: None.

OUTPUT: None.

USE: The user must set INT 1Fh to point to a supplied table. Figure 14-2 shows a sample table format.

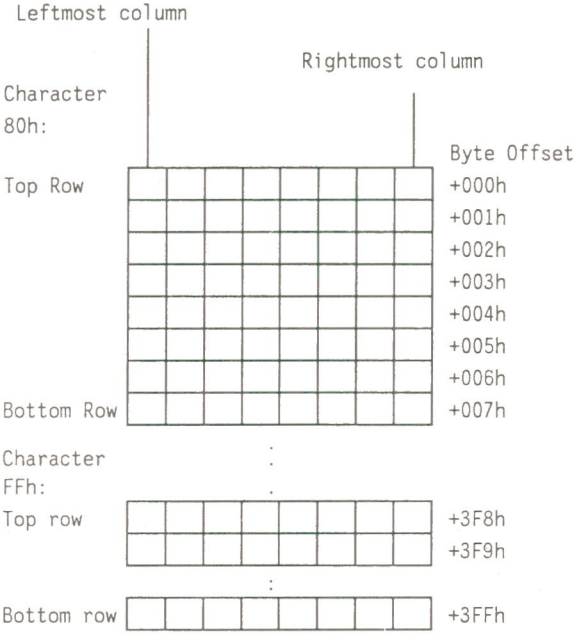


Figure 14-2. Sample Dot Table Format

Table Entries for 8 x 8 Dot Character Cells

The following paragraphs describe how to program video memory for 8 x 8 dot patterns.

For example: To make a question mark (?) the character for code 81h, begin at offset +008h (81h - 80h) x 8 = +008h. Left-justify alphanumeric characters in the cell. Visible dots are usually composed of two adjacent cells ON. The bottom row is normally blank (00h), except for descenders and special graphics characters.

Contents		Offset
78h	▪ ▪ ▪ ▪	+008h
CCh	▪ ▪ ▪ ▪	+009h
0Ch	▪ ▪	+00Ah
18h	▪ ▪	+00Bh
30h	▪ ▪	+00Ch
00h		+00Dh
30h	▪ ▪	+00Eh
00h		+00Fh

14.13 MISCELLANEOUS INTERRUPTS

This section contains information on the unused hardware interrupts and miscellaneous information locations in the BIOS ROM. There are seven unused interrupts available for use by optional interface boards and user-written applications or system software.

Table 14-49 lists the BIOS Miscellaneous Interrupts. Table 14-50 lists the memory locations used.

Table 14-49. Miscellaneous Interrupts

Interrupts Available	Type	Function
INT 0Ah	HW	Simulated IRQ2
INT 0Dh	HW	IRQ5
INT 71h	HW	IRQ9
INT 72h	HW	IRQ10
INT 73h	HW	IRQ11
INT 74h	HW	IRQ12
INT 77h	HW	IRQ15

Table 14-50. Memory Locations Used by Miscellaneous Interrupts

Memory Location	Bytes	Function/Vector
0000:0028	4	INT 0Ah
0000:0034	4	INT 0Dh
0000:01C4	4	INT 71h
0000:01C8	4	INT 72h
0000:01CC	4	INT 73h
0000:01D0	4	INT 74h
0000:01DC	4	INT 77h

INT 0Ah - HW - SIMULATED IRQ2
- CPU - INVALID TSS

INT 0Ah provides compatibility with 8088/8086-based products that expect pin B04 of the system bus to be IRQ2. On COMPAQ 80286-based products, bus pin B04 is actually connected to IRQ9, which is vectored through INT 71h. Therefore, for system compatibility with 8088/8086-based products, IRQ9 interrupts vectored through INT 71h are redirected by the BIOS to INT 0Ah.

INT 0Dh - HW - IRQ5
- CPU - GENERAL PROTECTION

INT 0Dh normally handles the interrupts from IRQ5, which is unused. However, if operating in the Protected mode, INT 0Dh is also issued by the 80286 when a General Protection exception is detected.

Operating system software running in the Protected mode can readily relocate hardware interrupts IRQ0 through IRQ7 to another block of eight interrupt vectors to avoid conflict with CPU-type INT 0Dh. (See INT 15h, AH = 89h.)

INT 71h - HW - IRQ9

INT 71h receives the interrupts from IRQ9.

On COMPAQ 80286-based products, bus pin B04 is connected to IRQ9, which is vectored through INT 71h.

INT 72h - HW - IRQ10

INT 72h receives the interrupts from IRQ10.

Should an INT 72h occur, BIOS performs an interrupt return.

INT 73h - HW - IRQ11

INT 73h receives the interrupts from IRQ11.

Should an INT 73h occur, BIOS performs a Dummy Interrupt Return.

INT 74h - HW - IRQ12

INT 74h receives the interrupts from IRQ12.

Should an INT 74h occur, BIOS performs a Dummy Interrupt Return.

INT 77h - HW - IRQ15

INT 77h receives the interrupts from IRQ15.

Should an INT 77h occur, BIOS performs a Dummy Interrupt Return.

14.14 SPECIAL BIOS ROM LOCATIONS

The ROM memory locations described in the following sections are supplied in COMPAQ products.

Table 14-51 lists the special BIOS ROM locations.

Table 14-51. Special BIOS ROM Locations

Address	Bytes	Function
F000:FFE6	2	Revision Code
F000:FFE8	2	BIOS Type Code
F000:FFEA	6	Machine ID
F000:FFFE	1	Machine Type Code

ROM Revision Code

The BIOS ROM contains a 2-byte revision code at address F000:FFE6. The contents of this memory location are in printable ASCII, left-justified and blank filled (if necessary).

BIOS Type Code

The BIOS type is identified by a 2-byte ASCII code at address F000:FFE8. The contents of this memory location are 30h, 31h ("0","1").

Machine ID

COMPAQ Personal Computers can be identified by a 6-byte string at address F000:FFEA that contains "COMPAQ" in uppercase ASCII.

Machine-Type Code

The machine type is identified by a 1-byte code at address F000:FFFE. It contains FCh for COMPAQ 286-based products. The machine-type code is provided for compatibility with 80286-based software.

Appendix A
ERROR MESSAGES

ERROR MESSAGES

The following pages list the error codes and a brief description of the probable source of the error.

Common Power-On Messages

Table A-1 lists the messages that could occur when the system is turned on or reset.

Table A-1. Power-On Messages

Message	Beeps	Probable Cause
163-Time & Date Not Set	2S	Invalid Time
(One very short beep)	1VS	Power-up Successful; FAST (8 MHz) Speed
(Two very short beeps)	2VS	Power-up Successful; System-board DIP Switch Selected Speed (HIGH or AUTO)
RESUME = "F1" KEY	None	Any Failure

Initialization Diagnostic Messages

Table A-2 lists error messages that may occur as part of the Power-On Self-Test (POST).

Table A-2. Power-On Self-Test (Post) Messages

Message	Beeps	Probable Cause
101-I/O ROM Error	1L, 1S	Option ROM checksum
101-ROM Error	1L, 1S	System ROM checksum
102-System Board Failure	None	DMA, timers, etc.
102-System or Memory Board Failure	None	High-order addresses
162-System Options Error	2S	No diskette drives or mismatch in drive types
162-System Options Not Set-(Run Setup)	2S	System configuration
164-Memory Size Error	2S	Memory size discrepancy
XX000Y ZZ 201-Memory Error	None	RAM failure
XX000Y ZZ 203-Memory Address Error	2S	Memory high address error
301-Keyboard Error	None	Keyboard failure
301-Keyboard Error or Test Fixture Installed	None	Keyboard test fixture
302-System Unit Security Lock is Locked - Unlock System Unit Security Lock	2S	System locked
303-Keyboard Controller Error	None	Keyboard controller
304-Keyboard or System Unit Error	None	Keyboard interface
402-Monochrome Adapter Failure	1L, 2S	Mono display controller
501-Display Adapter Failure	1L, 2S	Graphics display controller
601-Diskette Controller Error	None	Diskette controller
602-Diskette Boot Record Error	None	Diskette does not have a valid boot record

(Continued)

Table A-2. (Continued)

Message	Beeps	Probable Cause
702-Coprocessor Detection Error	None	Switch setting does not agree with 80287 detection
1780-Disk 0 Failure	None	Fixed disk drive 0 not ready
1781-Disk 1 Failure	None	Fixed disk drive 1 not ready
1782-Disk Controller Failure	None	Fixed disk drive controller
1790-Disk 0 Error	None	Fixed disk drive 0 access error
1791-Disk 1 Error	None	Fixed disk drive 1 access error
Parity Check 2 XX000Y ZZ	None	Parity RAM failure

Notes: 1. Tables A-13, A-14, and A-15 define XX, Y, and ZZ.
2. L means a long beep, and S means a short beep.

Advanced Diagnostics Error Messages

The following tables list error messages that may occur during testing by the advanced diagnostics.

Processor

Table A-3 lists error messages that relate to the 80386 microprocessor or to other system board devices.

Table A-3. Processor Error Message

Message	Problem Failure
101-01	CPU test failed
102-01	Numeric co-processor initial status word incorrect
102-02	Numeric co-processor initial control word incorrect
102-03	Numeric co-processor tag word not all ones
102-04	Numeric co-processor tag word not all zeros
102-05	Numeric co-processor exchange command failed
102-06	Numeric co-processor masked exception incorrectly handled
102-07	Numeric co-processor unmasked exception incorrectly handled
102-08	Numeric co-processor wrong mask bit set in status register
102-14	Switch indicates no numeric co-processor present

(Continued)

Table A-3. (Continued)

Message	Problem Failure
102-15	Numeric co-processor is inoperative or socket is unoccupied
103-01	DMA page registers test failed
103-02	DMA byte controller test failed
103-03	DMA word controller test failed
104-01	Interrupt controller master test failed
104-02	Interrupt controller slave test failed
104-03	Interrupt controller software RTC is inoperative
105-01	Port 61 bit 6 not at zero
105-02	Port 61 bit 5 not at zero
105-03	Port 61 bit 3 not at zero
105-04	Port 61 bit 1 not at zero
105-05	Port 61 bit 0 not at zero
105-06	Port 61 bit 5 not at one
105-07	Port 61 bit 3 not at one
105-08	Port 61 bit 1 not at one
105-09	Port 61 bit 0 not at one
105-10	Port 61 I/O test failed
105-11	Port 61 bit 7 not at zero
105-12	Port 61 bit 2 not at zero
105-13	No interrupt generated by failsafe timer
105-14	NMI not triggered by failsafe timer
106-01	Keyboard controller self-test failed
107-01	CMOS RAM test failed
108-02	CMOS interrupt test failed

(Continued)

Table A-3. (Continued)

Message	Problem Failure
108-03	CMOS interrupt test, CMOS not properly initialized
109-01	CMOS clock load data test failed
109-02	CMOS clock rollover test failed
109-03	CMOS clock test, CMOS not properly initialized
110-01	Programmable timer load data test failed
110-02	Programmable timer dynamic test failed
111-01	Refresh detect test failed
112-01	Speed test slow mode out of range
112-02	Speed test mixed mode out of range
112-03	Speed test fast mode out of range
112-04	Unable to enter slow mode in speed test
112-05	Unable to enter mixed mode in speed test
112-06	Unable to enter fast mode in speed test
112-07	Speed test system error
113-01	Protected mode test failed
114-01	Speaker test failed

Memory

Table A-4 lists error messages for memory-related errors.

Table A-4. Memory Error Messages

Message	Probable Failure
201-01	Memory machine ID test failed
202-01	Memory system ROM checksum failed
203-01	Memory write/read test failed
203-02	Error during saving program memory in write/read test
203-03	Error during restore of program memory in write/read test
204-01	Memory address test failed
204-02	Error during saving program memory in address test
204-03	Error during restore of program memory in address test
205-01	Walking I/O test failed
205-02	Error during saving program memory in walking I/O test
205-03	Error during restore of program memory in walking I/O test
205-04	Insufficient memory to perform test

Keyboard

Table A-5 lists error messages for keyboard-related errors.

Table A-5. Keyboard Error Messages

Message	Probable Failure
301-01	Keyboard short test, 8042 self-test failed
301-02	Keyboard short test, interface test failed
301-03	Keyboard short test, echo test failed
301-04	Keyboard short test, keyboard reset failed (286/386 only)
301-05	Keyboard short test, keyboard reset failed (88/86 only)
302-01	Keyboard long test, failed
302-02	Remaining unstruck keys
303-01	Keyboard LED test, 8042 self-test failed
303-02	Keyboard LED test, reset test failed
303-03	Keyboard LED test, reset failed
303-04	Keyboard LED test, LED command test failed
303-05	Keyboard LED test, LED command test failed
303-06	Keyboard LED test, LED command test failed
303-07	Keyboard LED test, LED command test failed
303-08	Keyboard LED test, command byte restore test failed
303-09	Keyboard LED test, LEDs failed to light
304-01	Keyboard typematic test failed
304-02	Unable to enter mode 3
304-03	Incorrect scan code from keyboard
304-04	No make code observed
304-05	Unable to disable repeat key feature
315-01	Security lock inoperative
315-02	Security lock stuck in locked position

Printer

Table A-6 lists error messages for printer-related errors.

Table A-6. Printer Error Messages

Message	Probable Failure
401-01	Printer connected test failed
402-01	Printer Data register failed
402-02	Printer Control register failed
402-03	Printer Data and control registers failed
402-04	Printer Loopback failed
402-05	Printer Loopback and data registers failed
402-06	Printer Loopback and control registers failed
402-07	Printer Loopback, data and control registers failed
402-08	Printer Interrupt test failed
402-09	Printer Interrupt and data registers failed
402-10	Printer Interrupt and control registers failed
402-11	Printer Interrupt, control and data registers failed
402-12	Printer Interrupt and loopback failed
402-13	Printer Interrupt, loopback, data registers failed
402-14	Printer Interrupt, loopback, control registers failed
402-15	Printer Interrupt, loopback, control and data registers failed
402-16	Printer unexpected interrupt received
403-01	Printer pattern test failed
498-00	Printer failed or not connected

Video

Table A-7 lists error messages for video-related errors.

Table A-7. Video Error Messages

Message	Probable Failure
501-01	VDU controller test failed
502-01	VDU memory test failed
503-01	VDU attribute test failed
504-01	VDU character set test failed
505-01	VDU 80x25 mode 9x14 char cell test failed
506-01	VDU 80x25 mode 8x8 char cell test failed
507-01	VDU 40x25 mode test failed
508-01	VDU 320x200 mode color set 0 test failed
509-01	VDU 320x200 mode color set 1 test failed
510-01	VDU 640x200 mode test failed
511-01	VDU Screen memory page test failed
512-01	VDU Gray scale test failed
514-01	VDU White screen test failed
516-01	VDU Noise pattern test failed
517-01	Light pen text mode test failed - no response
517-02	Light pen text mode test failed - invalid response
517-03	Light pen medium resolution mode test failed - no response
517-04	Light pen medium resolution mode test failed - invalid response

Diskette Drive

Table A-8 lists error messages for diskette-related errors.

Table A-8. Diskette Drive Error Messages

Message	Probable Failure
600-xx	Floppy ID test
05	Failed to reset controller
20	Failed to get drive type
601-xx	Floppy format
05	Failed to reset controller
09	Failed to format a track
23	Failed to set drive type in ID media
602-xx	Floppy read test
01	Exceeded max soft error limit
02	Exceeded max hard error limit
03	Previously exceeded max soft error limit
04	Previously exceeded max hard error limit
05	Failed to reset controller
06	Fatal error while reading
603-xx	Floppy write read compare test
01	Exceeded max soft error limit
02	Exceeded max hard error limit
03	Previously exceeded max soft error limit
04	Previously exceeded max hard error limit
05	Failed to reset controller
06	Fatal error while reading
07	Fatal error while writing
08	Failed compare of write/read buffers
604-xx	Floppy random seek test
01	Exceeded max soft error limit
02	Exceeded max hard error limit
03	Previously exceeded max soft error limit
04	Previously exceeded max hard error limit
05	Failed to reset controller
06	Fatal error while reading
605-xx	Floppy ID media test
20	Failed to get drive type
24	Failed to read floppy media
25	Failed to verify floppy media
606-xx	Floppy speed test
26	Failed to read media in speed test
27	Failed speed limits
607-xx	Floppy wrap test
10	Failed sector wrap test
608-xx	Floppy write protect test
28	Failed write protect test
609-xx	Floppy reset controller test
05	Failed to reset controller
610-xx	Floppy change line test
21	Failed to get change line status
22	Failed to clear change line status
694-00	Pin 34 not cut
697-00	Diskette type error
698-00	Diskette drive speed not within limits
699-00	Drive/media ID error - Rerun SETUP

Serial Communications

Table A-9 lists error messages for serial communications-related errors.

Table A-9. Serial Communications Error Messages

Message	Probable Failure
11xx-yy	Serial port test failed
01-01	UART DLAB bit failure
01-02	Line input or UART fault
01-03	Address line fault
01-04	Data line fault
01-05	UART control signal failure
01-06	UART THRE bit failure
01-07	UART DATA READY bit failure
01-08	UART TX/RX buffer failure
01-09	INTERRUPT circuit failure
01-10	COM 1 set to invalid interrupt
01-11	COM 2 set to invalid interrupt
01-12	DRIVE/RECEIVER control signal failure
01-13	UART control signal interrupt failure
01-14	DRIVER/RECEIVER data failure
09-01	Clock register initialization failure
09-02	Clock register rollover failure
09-03	Clock reset failure
09-04	Input line or clock failure
09-05	Address line fault
09-06	Data line fault

Modem

Table A-10 lists error messages for serial communications-related errors.

Table A-10. Modem Error Messages

Message	Probable Failure
1201-xx	Modem Internal Loopback Test
01	UART DLAB bit failure
02	Line input or UART fault
03	Address line fault
04	Data line fault
05	UART control signal failure
06	UART THRE bit failure
07	UART DATA READY bit failure
08	UART TX/RX buffer failure
09	INTERRUPT circuit failure
10	COM 1 set to interrupt 3
11	COM 2 set to interrupt 4
12	DRIVER/RECEIVER control signal failure
13	UART control signal interrupt failure
14	DRIVE/RECEIVER data failure
15	Modem detection failure
16	Modem ROM checksum failure
17	Tone detection failure
1202-01	Modem Timed out waiting for SYNC
02	Modem Timed out waiting for modem response
03	Modem Exceeded data block retry limit
1203-xx	Modem External Termination Test
01	Modem external TIP/RING failure
02	Modem external DATA TIP/RING failure
03	Modem line termination failure

(Continued)

Table A-10. (Continued)

Message	Probable Failure
1204-xx	Modem Auto Originate Test
01	Modem Timed out waiting for SYNC
02	Modem Timed out waiting for modem response
03	Modem exceeded data block retry limit
04	RCV exceeded carrier lost limit
05	XMIT exceeded carrier lost limit
06	Timed out waiting for Dial Tone
07	Dial number string too long
08	Modem timed out waiting for remote response
09	Modem exceeded maximum re-dial limit
10	Line Quality prevented remote connection
11	Modem timed out waiting for remote connection
1205-xx	Modem Auto Answer Test
01	Modem Timed out waiting for SYNC
02	Modem Timed out waiting for modem response
03	Modem exceeded data block retry limit
04	RCV exceeded carrier lost limit
05	XMIT exceeded carrier lost limit
06	Timed out waiting for Dial Tone
07	Dial number string too long
08	Modem timed out waiting for remote response
09	Modem exceeded maximum re-dial limit
10	Line Quality prevented remote connection
11	Modem timed out waiting for remote connection

(Continued)

Table A-10. (Continued)

Message	Probable Failure
1210-xx	Modem Direct Connect Test
01	Modem Timed out waiting for SYNC
02	Modem Timed out waiting for modem response
03	Modem exceeded data block retry limit
04	RCV exceeded carrier lost limit
05	XMIT exceeded carrier lost limit
06	Timed out waiting for Dial Tone
07	Dial number string too long
08	Modem timed out waiting for remote response
09	Modem exceeded maximum re-dial limit
10	Line Quality prevented remote connection
11	Modem timed out waiting for remote connection

Fixed Disk Drive

Table A-11 lists error messages for fixed disk-related errors.

Table A-11. Fixed Disk Drive Error Messages

Message	Probable Failure
1700-xx	Hard disk ID test
05	Failed to reset controller
09	Failed to format a track
42	Recalibrate drive failed
45	Failed to get drive parameters from ROM
46	Invalid drive parameters found in ROM
66	Failed init drive parameter
69	Failed to read drive size from controller
70	Failed translate mode
71	Failed non-translated mode
1701-xx	Hard disk format test
05	Failed to reset controller
09	Failed to format a cylinder
42	Recalibrate drive failed
58	Failed to write sector buffer
59	Failed to read sector buffer
66	Failed init drive parameter

(Continued)

Table A-11. (Continued)

Message	Problem Failure
1702-xx	Hard disk read test
01	Exceeded max soft error limit
02	Exceeded max hard error limit
03	Previously exceeded max soft error limit
04	Previously exceeded max hard error limit
05	Failed to reset controller
06	Fatal error while reading
40	Failed cylinder 0
65	Exceeded max bad sector per track
68	Failed to read long
70	Failed translate mode
71	Failed non-translated mode
1703-xx	Hard disk write read compare test
01	Exceeded max soft error limit
02	Exceeded max hard error limit
03	Previously exceeded max soft error limit
04	Previously exceeded max hard error limit
05	Failed to reset controller
06	Fatal error while reading
07	Fatal error while writing
08	Failed compare of write/read buffers
40	Cylinder 0 error
55	Cylinder 1 error
63	Failed soft error rate
65	Exceeded max bad sector per track
67	Failed to write long

(Continued)

Table A-11. (Continued)

Message	Problem Failure
1703-xx	Hard disk write read compare test
68	Failed to read long
70	Failed translate mode
71	Failed non-translate mode
1704-xx	Hard disk random seek test
01	Exceeded max soft error limit
02	Exceeded max hard error limit
03	Previously exceeded max soft error limit
04	Previously exceeded max hard error limit
05	Failed to reset controller
06	Fatal error while reading
40	Cylinder 0 error
55	Cylinder 1 error
65	Exceeded max bad sector per track
70	Failed translate mode
71	Failed non-translate mode
1705-xx	Hard disk controller test
05	Failed to reset controller
44	Failed hard disk controller diagnostics
56	Failed controller RAM diagnostics
57	Failed controller to drive diagnostics
1706-xx	Hard disk drive ready test
41	Drive not ready
1707-xx	Hard disk recalibrate test
42	Failed to recalibrate drive

(Continued)

Table A-11. (Continued)

Message	Problem Failure
1708-xx	Hard disk format bad track test
02	Exceeded max hard error limit
05	Failed to reset controller
09	Format track bad failed
42	Recalibrate drive failed
43	Failed to format a cylinder bad
58	Failed to write sector buffer
59	Failed to read sector buffer
1709-xx	Hard disk reset controller test
05	Failed to reset controller
1710-xx	Hard disk park head test
45	Failed to get drive parameters from ROM
47	Failed to park heads
1714-xx	Hard disk file write test
01	Exceeded max soft error limit
02	Exceeded max hard error limit
03	Previously exceeded max soft error limit
04	Previously exceeded max hard error limit
05	Failed to reset controller
06	Fatal error while reading
07	Fatal error while writing
08	Failed compare of write/read buffers
10	Failed floppy sector wrap during read
20	Failed to get floppy drive type
24	Failed to read floppy media
25	Failed to verify floppy media

(Continued)

Table A-11. (Continued)

Message	Problem Failure
1714-xx	Hard disk file write test
48	Failed to move disk table to RAM
49	Failed to read floppy media in file write test
50	Failed File I/O write test
51	Failed File I/O read test
52	Failed File I/O compare test
55	Failed cylinder 1
65	Exceeded max bad sector per track
70	Failed translate mode
71	Failed non-translate mode
1715-xx	Hard disk head select test
45	Failed to get drive parameters from ROM
53	Failed Drive/Head register test
54	Failed Digital Input register test
1716-xx	Hard disk conditional format test
01	Exceeded max soft error limit
02	Exceeded max hard error limit
05	Failed to reset controller
06	Fatal error while reading
07	Fatal error while writing
08	Failed compare of write/read buffers
09	Failed to format a cylinder
40	Cylinder 0 error
42	Failed recalibrate
55	Cylinder 1 error

(Continued)

Table A-11. (Continued)

Message	Problem Failure
1716-xx	Hard disk conditional format test
58	Failed to write sector buffer
59	Failed to read sector buffer
60	Failed to compare sector buffer
65	Exceeded max bad sector per track
66	Failed init drive parameter
70	Failed translate mode
71	Failed non-translate mode
1717-xx	Hard disk ECC test
01	Exceeded max soft error limit
02	Exceeded max hard error limit
03	Previously exceeded max soft error limit
04	Previously exceeded max hard error limit
05	Reset controller failed
06	Fatal error while reading (BIOS st. >= 0x20)
07	Fatal error while writing
08	Failed compare of write/read buffers
40	Cylinder 0 failed
55	Cylinder 1 failed
61	Failed uncorrectable error
62	Failed correctable error
65	Exceeded max bad sector per track
67	Failed to write long
68	Failed to read long
70	Failed translate mode
71	Failed non-translate mode
1799-00	Invalid fixed disk drive type

Fixed Disk Drive Backup (Tape)

Table A-12 lists fixed disk drive backup-related errors.

Table A-12. Fixed Disk Drive Backup (Tape) Error Messages

Message	Probable Cause
1900-xx	Tape ID
01	Drive not installed
02	Drive installed in other drive 3
26	Can not identify drive
27	Drive not compatible with controller
1901-xx	Tape servo write
01	Drive not installed
02	Cartridge not installed
03	Tape motion error
04	Drive busy error
05	Track seek error
06	Tape write protected error
07	Tape already servo written
08	Unable to servo write
11	Drive recalibration error
21	Got servo pulses 2'nd time but not 1'st
22	Never got to EOT after servo check
25	Unable to erase cartridge
27	Drive not compatible with controller
1902-xx	Tape format
01	Drive not installed
02	Cartridge not installed

(Continued)

Table A-12. (Continued)

Message	Problem Failure
1902-xx	Tape format
03	Tape motion error
04	Drive busy error
05	Track seek error
06	Tape write protected error
09	Unable to format
10	Format mode error
11	Drive recalibration error
12	Tape not servo written
13	Tape not formatted
21	Got servo pulses 2'nd time but not 1'st
22	Never got to EOT after servo check
27	Drive not compatible with controller
28	Format gap error
1903-xx	Tape drive sensor test
01	Drive not installed
27	Drive not compatible with controller
1904-xx	Tape BOT EOT test
01	Drive not installed
02	Cartridge not installed
03	Tape motion error
04	Drive busy error
05	Track seek error
15	Sensor error flag
27	Drive not compatible with controller

(Continued)

Table A-12. (Continued)

Message	Problem Failure
1905-xx	Tape read test
01	Drive not installed
02	Cartridge not installed
03	Tape motion error
04	Drive busy error
05	Track seek error
14	Drive timeout error
16	Block locate (block ID) error
17	Soft error limit exceeded
18	Hard error limit exceeded
19	Write error (probably ID error)
27	Drive not compatible with controller
1906-xx	Tape write/read/compare test
01	Drive not installed
02	Cartridge not installed
03	Tape motion error
04	Drive busy error
05	Track seek error
06	Tape write protected error
14	Drive timeout error
16	Block locate (block ID) error
17	Soft error limit exceeded
18	Hard error limit exceeded
19	Write (probably ID error)
27	Drive not compatible with controller

Enhanced Color Graphics

Table A-13 lists the Enhanced Color Graphics Controller Board related errors.

Table A-13. Enhanced Color Graphics Error Messages

Message	Probable Failure
2402-01	VDU memory test failed
2403-01	VDU attribute test failed
2404-01	VDU character set test failed
2405-01	VDU 80x25 mode 9x14 char cell test failed
2406-01	VDU 80x25 mode 8x8 char cell test failed
2407-01	VDU 40x25 mode test failed
2408-01	VDU 320x200 mode color set 0 test failed
2409-01	VDU 320x200 mode color set 1 test failed
2410-01	VDU 640x200 mode test failed
2411-01	VDU Screen memory page test failed
2412-01	VDU Gray scale test failed
2414-01	VDU White screen test failed
2416-01	VDU Noise pattern test failed
2417-01	Lightpen text mode test failed - no response
2417-02	Lightpen text mode test failed - invalid response

(Continued)

Table A-13. (Continued)

Message	Probable Failure
2417-03	Lightpen medium res. mode test failed - no response
2417-04	Lightpen medium res. mode failed - invalid response
2418-01	ECG memory test failed
2418-02	ECG shadow RAM test failed
2419-01	ECG ROM checksum test failed
2420-01	ECG attribute test failed
2421-01	ECG 640x200 graphics mode test failed
2422-01	ECG 640x350 16 color set test failed
2423-01	ECG 640x350 64 color set test failed
2424-01	ECG monochrome text mode test failed
2425-01	ECG monochrome graphics mode test failed

Memory-Error Codes

Memory-error codes result when the system detects a memory fault during the power-on self-test or as a result of a diagnostic test. The test programs attempt to isolate the memory fault to a specific chip, then generate a memory-error code that specifies which memory chip to replace.

In some cases, replacing the memory chip will not solve the problem because: 1) the system may not be able to accurately determine which chip or chips are at fault, and 2) the problem may be due to a failure in the memory-support circuitry, not the memory device.

If replacing the indicated memory devices does not solve the problem, return your system to an Authorized COMPAQ Dealer for service. Memory boards with soldered memory devices should also be returned to an Authorized COMPAQ Dealer for service.

The memory-error code points to a specific memory address. The physical location of the memory address depends on the type of system, the number and type of memory boards installed, and type of memory device used (64K RAMs or 256K RAMs).

This section provides 10 tables to help you identify which memory device to replace when the system shows a memory error. Use the following charts to determine which of the 10 tables to use to find the suspected defective chip.

A-13. COMPAQ PORTABLE 286 Memory Configurations

System Board RAM Type	Error Code XX Value	Memory Device Location	Lookup Table
64K	00 to 02 (0-256 KB)	System Board	1
	10 to 2E (1-3 MB)	Memory Expansion Board	3
256K	00 to 08 (0-640 KB)	System Board	2
	10 to 2E (1-3 KB)	Memory Expansion Board	3
64K	00 to 08 (0-640 KB)	System Memory Board	4
	00 to 08 (0-640 KB)	Version 2 System Board	6
	10 to 2E (1-3 MB)	Memory Expansion Board	3

Note: XX codes 0A to 0F represent the memory space for the video memory and system ROMs. Errors in the video memory or system ROM space are not reported in the XX000B YYZZ error message format.

(Continued)

A-13. (Continued)

System Board RAM Type	Error Code XX Value	Memory Device Location	Lookup Table
256K	00 to 08, 10 to 26 (0-640 KB, 1-2.5 MB)	System Memory Board	5
	00 to 08, 10 to 26 (0-640 KB, 1-2.5 MB)	Version 2 System Board	9
	28 to 46 (2.5-4.5 MB)	Memory Expansion Board	6
	48 to 66 (4.5-6.5 MB)	Memory Expansion Board	7
	68 to 86 (6.5-8.5 MB)	Memory Expansion Board	10

Note: XX codes 0A to 0F represent the memory space for the video memory and system ROMs. Errors in the video memory or system ROM space are not reported in the XX000B YYZZ error message format.

Table 1. Defective Memory Chip Isolation Map for the COMPAQ PORTABLE 286 System Board using 64K RAMs (0-256 KB)

Memory-error codes are in the format XX000B YYZZ.
XX equals the 128-KB memory segment in which an error is detected.
000 is always equal to 000 (not used)
B identifies whether the defective memory chip is in the high byte or the low byte of the memory bank.
When B = 0, YY defines the defective-chip row location within the low byte of the memory bank.
When B = 1, ZZ defines the defective-chip row location within the high byte of the memory bank.
For example, the memory-error message "020001 0010" specifies chip U50.

Use the following chart to locate a defective memory chip:

	XX = 00 Bank 0		XX = 02 Bank 1	
Data Bit	B = 0	B = 1	B = 0	B = 1
YY or ZZ	Low	High	Low	High
01	U5	U6	U7	U8
02	U20	U21	U22	U23
04	U25	U26	U27	U28
08	U41	U42	U43	U44
10	U47	U48	U49	U50
20	U63	U64	U65	U66
40	U70	U71	U72	U73
80	U81	U82	U83	U84
00	U88	U89	U90	U91

Table 2. Defective Memory Chip Isolation Map for the COMPAQ PORTABLE 286 System Board using 256K RAMs (0-640 KB)

Memory-error codes are in the format XX000B YYZZ.
- XX equals the 128-KB memory segment in which an error is detected.
- 000 is always equal to 000 (not used)
- B identifies whether the defective memory chip is in the high byte or the low byte of the memory bank.
- When B = 0, YY defines the defective-chip row location within the low byte of the memory bank.
- When B = 1, ZZ defines the defective-chip row location within the high byte of the memory bank.

For example, the memory-error message "020000 0100" specifies chip U7.

Use the following chart to locate a defective memory chip:

	XX = 00		XX = 02, 04, 06, 08	
	Bank 0		Bank 1	
Data Bit	B = 0	B = 1	B = 0	B = 1
YY or ZZ	Low	High	Low	High
01	U5	U6	U7	U8
02	U20	U21	U22	U23
04	U25	U26	U27	U28
08	U41	U42	U43	U44
10	U47	U48	U49	U50
20	U63	U64	U65	U66
40	U70	U71	U72	U73
80	U81	U82	U83	U84
00	U88	U89	U90	U91

Table 3. Defective Memory Chip Isolation Map for a Memory Expansion Board Mapped into the 1-3 MB Memory Space (256 KB RAMs)

This isolation map is valid for a system memory board that uses 64K RAMs.
Memory-error codes are in the format XX000B YYZZ.
XX equals the 128-KB memory segment in which an error is detected.
000 is always equal to 000 (not used)
B identifies whether the defective memory chip is in the high byte or the low byte of the memory bank.
When B = 0, YY defines the defective-chip row location within the low byte of the memory bank.
When B = 1, ZZ defines the defective-chip row location within the high byte of the memory bank.
For example, the memory-error message "240000 0100" specifies chip U55.

Use the following chart to locate a defective memory chip:

	XX = 10, 12, 14, 16, Bank 1		XX = 18, 1A, 1C, 1E, Bank 2		XX = 20, 22, 24, 26, Bank 3		XX = 28, 2A 2C, 2E Bank 4	
Data Bit	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0
YY or ZZ	High	Low	High	Low	High	Low	High	Low
80	U3	U12	U21	U30	U39	U48	U57	U66
40	U4	U13	U22	U31	U40	U49	U58	U67
20	U5	U14	U23	U32	U41	U50	U59	U68
10	U6	U15	U24	U33	U42	U51	U60	U69
08	U7	U16	U25	U34	U43	U52	U61	U70
04	U8	U17	U26	U35	U44	U53	U62	U71
02	U9	U18	U27	U36	U45	U54	U63	U72
01	U10	U19	U28	U37	U46	U55	U64	U73
00	U11	U20	U29	U38	U47	U56	U65	U74

Table 4. Defective Memory Chip Isolation Map for the COMPAQ DESKPRO 286 System Memory Board using 64K RAMs (0-640 KB)

The memory-error code is in the format XX000B YYZZ.
XX equals the 128-KB memory segment in which an error is detected.
000 is always equal to 000 (not used)
B identifies whether the defective memory chip is in the high byte or the low byte of the memory bank.
When B = 0, YY defines the defective-chip row location within the low byte of the memory bank.
When B = 1, ZZ defines the defective-chip row location within the high byte of the memory bank.
For example, the memory-error message "040001 0010" specifies chip U24.

Use the following chart to locate a defective memory chip:

	XX = 00 Bank 0		XX = 02 Bank 1		XX = 04 Bank 2		XX = 06 Bank 3		XX = 08 Bank 4	
Data Bit	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0
YY or ZZ	High	Low	High	Low	High	Low	High	Low	High	Low
80	U1	U2	U3	U12	U21	U30	U39	U48	U57	U66
40			U4	U13	U22	U31	U40	U49	U58	U67
20			U5	U14	U23	U32	U41	U50	U59	U68
10			U6	U15	U24	U33	U42	U51	U60	U69
08			U7	U16	U25	U34	U43	U52	U61	U70
04			U8	U17	U26	U35	U44	U53	U62	U71
02			U9	U18	U27	U36	U45	U54	U63	U72
01			U10	U19	U28	U37	U46	U55	U64	U73
00			U11	U20	U29	U38	U47	U56	U65	U74

Table 5. Defective Memory Chip Isolation Map for the COMPAQ DESKPRO 286 System Memory Board using 256K RAMs (0-640 KB, 1-2.5 MB)

Memory-error codes are in the format XX000B YYZZ.
XX equals the 128-KB memory segment in which an error is detected.
000 is always equal to 000 (not used)
B identifies whether the defective memory chip is in the high byte or the low byte of the memory bank.
When B = 0, YY defines the defective-chip row location within the low byte of the memory bank.
When B = 1, ZZ defines the defective-chip row location within the high byte of the memory bank.
For example, the memory-error message "040001 0010" specifies chip U6.

Use the following chart to locate a defective memory chip:

	XX = 00		XX = 02, 04, 06, 08		XX = 10, 12, 14, 16		XX = 18, 1A, 1C, 1E		XX = 20, 22, 24, 26	
	Bank 0		Bank 1		Bank 2		Bank 3		Bank 4	
Data Bit	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0
YY or ZZ	High	Low	High	Low	High	Low	High	Low	High	Low
80	U1	U2	U3	U12	U21	U30	U39	U48	U57	U66
40			U4	U13	U22	U31	U40	U49	U58	U67
20			U5	U14	U23	U32	U41	U50	U59	U68
10			U6	U15	U24	U33	U42	U51	U60	U69
08			U7	U16	U25	U34	U43	U52	U61	U70
04			U8	U17	U26	U35	U44	U53	U62	U71
02			U9	U18	U27	U36	U45	U54	U63	U72
01			U10	U19	U28	U37	U46	U55	U64	U73
00			U11	U20	U29	U38	U47	U56	U65	U74

Table 6. Defective Memory Chip Isolation Map for the COMPAQ DESKPRO 286 Version 2 System Board using 64K RAMs (0-640 KB)

The memory-error code is in the format XX000B YYZZ.
XX equals the 128-KB memory segment in which an error is detected.
000 is always equal to 000 (not used)
B identifies whether the defective memory chip is in the high byte or the low byte of the memory bank.
When B = 0, YY defines the defective-chip row location within the low byte of the memory bank.
When B = 1, ZZ defines the defective-chip row location within the high byte of the memory bank.
For example, the memory-error message "040001 0010" specifies chip U96.

Use the following chart to locate a defective memory chip:

	XX = 00 Bank 0		XX = 02 Bank 1		XX = 04 Bank 2		XX = 06 Bank 3		XX = 08 Bank 4	
Data Bit	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0
YY or ZZ	High	Low	High	Low	High	Low	High	Low	High	Low
80	U124	U107	U121	U118	U93	U82	U66	U52	U40	U27
40	U125	U108			U94	U83	U67	U53	U41	U28
20	U126	U109			U95	U84	U68	U54	U42	U29
10	U127	U110			U96	U85	U69	U55	U43	U30
08	U128	U111	U120	U117	U97	U86	U70	U56	U44	U31
04	U129	U112			U98	U87	U71	U57	U45	U32
02	U130	U113			U99	U88	U72	U58	U46	U33
01	U131	U114			U100	U89	U73	U59	U47	U34
00	U132	U115	U122	U119	U101	U90	U74	U60	U48	U35

Table 7. Defective Memory Chip Isolation Map for the COMPAQ DESKPRO 286 Version 2 System Board using 256K RAMs (0-640 KB, 1-2.5 MB)

The memory-error code is in the format XX000B YYZZ.
XX equals the 128-KB memory segment in which an error is detected.
000 is always equal to 000 (not used)
B identifies whether the defective memory chip is in the high byte or the low byte of the memory bank.
When B = 0, YY defines the defective-chip row location within the low byte of the memory bank.
When B = 1, ZZ defines the defective-chip row location within the high byte of the memory bank.
For example, the memory-error message "040001 0010" specifies chip U121.

Use the following chart to locate a defective memory chip:

	XX = 00		XX = 02, 04, 06, 08		XX = 10, 12, 14, 16		XX = 18, 1A, 1C, 1E		XX = 20, 22, 24, 26	
	Bank 0		Bank 1		Bank 2		Bank 3		Bank 4	
Data Bit	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0
YY or ZZ	High	Low	High	Low	High	Low	High	Low	High	Low
80	U124	U107	U121	U118	U93	U82	U66	U52	U40	U27
40	U125	U108			U94	U83	U67	U53	U41	U28
20	U126	U109			U95	U84	U68	U54	U42	U29
10	U127	U110			U96	U85	U69	U55	U43	U30
08	U128	U111	U120	U117	U97	U86	U70	U56	U44	U31
04	U129	U112			U98	U87	U71	U57	U45	U32
02	U130	U113			U99	U88	U72	U58	U46	U33
01	U131	U114			U100	U89	U73	U59	U47	U34
00	U132	U115	U122	U119	U101	U90	U74	U60	U48	U35

Table 8. Defective Memory Chip Isolation Map for a Memory Expansion Board Mapped into the 2.5-4.5 MB Memory Space (256 KB RAMs)

This isolation map is valid for a system memory board that uses 256K RAMs.
Memory-error codes are in the format XX000B YYZZ.
XX equals the 128-KB memory segment in which an error is detected.
000 is always equal to 000 (not used)
B identifies whether the defective memory chip is in the high byte or the low byte of the memory bank.
When B = 0, YY defines the defective-chip row location within the low byte of the memory bank.
When B = 1, ZZ defines the defective-chip row location within the high byte of the memory bank.
For example, the memory-error message "2A0001 0080" specifies chip U3.

Use the following chart to locate a defective memory chip:

	XX = 28, 2A, 2C, 2E Bank 1		XX = 30, 32, 34, 36 Bank 2		XX = 38, 3A, 3C, 3E Bank 3		XX = 40, 42, 44, 46 Bank 4	
Data Bit	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0
YY or ZZ	High	Low	High	Low	High	Low	High	Low
80	U3	U12	U21	U30	U39	U48	U57	U66
40	U4	U13	U22	U31	U40	U49	U58	U67
20	U5	U14	U23	U32	U41	U50	U59	U68
10	U6	U15	U24	U33	U42	U51	U60	U69
08	U7	U16	U25	U34	U43	U52	U61	U70
04	U8	U17	U26	U35	U44	U53	U62	U71
02	U9	U18	U27	U36	U45	U54	U63	U72
01	U10	U19	U28	U37	U46	U55	U64	U73
00	U11	U20	U29	U38	U47	U56	U65	U74

Table 9. Defective Memory Chip Isolation Map for a Memory Expansion Board Mapped into the 4.5-6.5 MB Memory Space (256 KB RAMs)

Memory-error codes are in the format XX000B YYZZ.
XX equals the 128-KB memory segment in which an error is detected.
000 is always equal to 000 (not used)
B identifies whether the defective memory chip is in the high byte or the low byte of the memory bank.
When B = 0, YY defines the defective-chip row location within the low byte of the memory bank.
When B = 1, ZZ defines the defective-chip row location within the high byte of the memory bank.
For example, the memory-error message "520000 0400" specifies chip U35.

Use the following chart to locate a defective memory chip:

	XX = 48, 4A, 4C, 4E Bank 1		XX = 50, 52, 54, 56 Bank 2		XX = 58, 5A, 5C, 5E Bank 3		XX = 60, 62, 64, 66 Bank 4	
Data Bit	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0
YY or ZZ	High	Low	High	Low	High	Low	High	Low
80	U3	U12	U21	U30	U39	U48	U57	U66
40	U4	U13	U22	U31	U40	U49	U58	U67
20	U5	U14	U23	U32	U41	U50	U59	U68
10	U6	U15	U24	U33	U42	U51	U60	U69
08	U7	U16	U25	U34	U43	U52	U61	U70
04	U8	U17	U26	U35	U44	U53	U62	U71
02	U9	U18	U27	U36	U45	U54	U63	U72
01	U10	U19	U28	U37	U46	U55	U64	U73
00	U11	U20	U29	U38	U47	U56	U65	U74

Table 10. Defective Memory Chip Isolation Map for a Memory Expansion Board Mapped into the 6.5-8.5 MB memory space (256K RAMs)

Memory-error codes are in the format XX000B YYZZ.
XX equals the 128-KB memory segment in which an error is detected.
000 is always equal to 000 (not used)
B identifies whether the defective memory chip is in the high byte or the low byte of the memory bank.
When B = 0, YY defines the defective-chip row location within the low byte of the memory bank.
When B = 1, ZZ defines the defective-chip row location within the high byte of the memory bank.
For example, the memory-error message "860000 0200" specifies chip U72.

Use the following chart to locate a defective memory chip:

	XX = 68, 6A, 6C, 6E		XX = 70, 72, 74, 76		XX = 78, 7A, 7C, 7E		XX = 80, 82, 84, 86	
	Bank 1		Bank 2		Bank 3		Bank 4	
Data Bit	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0	B = 1	B = 0
YY or ZZ	High	Low	High	Low	High	Low	High	Low
80	U3	U12	U21	U30	U39	U48	U57	U66
40	U4	U13	U22	U31	U40	U49	U58	U67
20	U5	U14	U23	U32	U41	U50	U59	U68
10	U6	U15	U24	U33	U42	U51	U60	U69
08	U7	U16	U25	U34	U43	U52	U61	U70
04	U8	U17	U26	U35	U44	U53	U62	U71
02	U9	U18	U27	U36	U45	U54	U63	U72
01	U10	U19	U28	U37	U46	U55	U64	U73
00	U11	U20	U29	U38	U47	U56	U65	U74

Appendix B

ASYNCHRONOUS COMMUNICATIONS/ PARALLEL PRINTER BOARD

Appendix B
ASYNCHRONOUS COMMUNICATIONS/
PARALLEL PRINTER BOARD

APPENDIX B
ASYNCHRONOUS COMMUNICATIONS/PARALLEL PRINTER BOARD

B.1 INTRODUCTION

The Asynchronous Communications/Parallel Printer Board supplies serial Asynchronous Communications functions as well as parallel printer communications functions.

The Asynchronous Communications functions are controlled through a 9-pin Asynchronous Communications port, enabling use of COM1 and COM2. The parallel printer functions are controlled through a 25-pin parallel printer port, enabling use of LPT1, LPT2, and LPT3. The settings for both of these ports are user selectable. By setting the positions of switches 1, 2, 3, 4, and 5 of switch bank 1 (SW1), which is located on the board the user can enable or disable both ports and their functions. (For a summary of switch settings, see Section B.5, Switches.)

Figure B-1 shows the component layout for the Asynchronous Communications/Parallel Printer Board. Figure B-2 shows its functional block diagram and Table B-1 lists the I/O port addresses and SW1 switch settings.

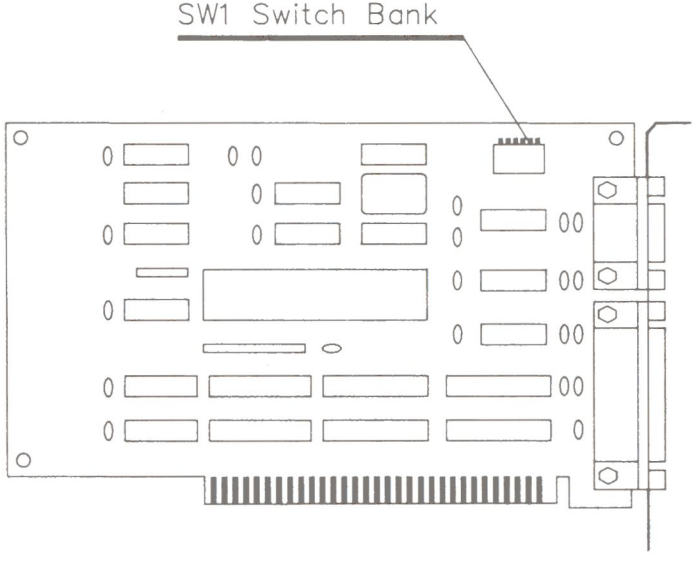


Figure B-1. Component Layout for the Asynchronous Communications/Parallel Printer Board

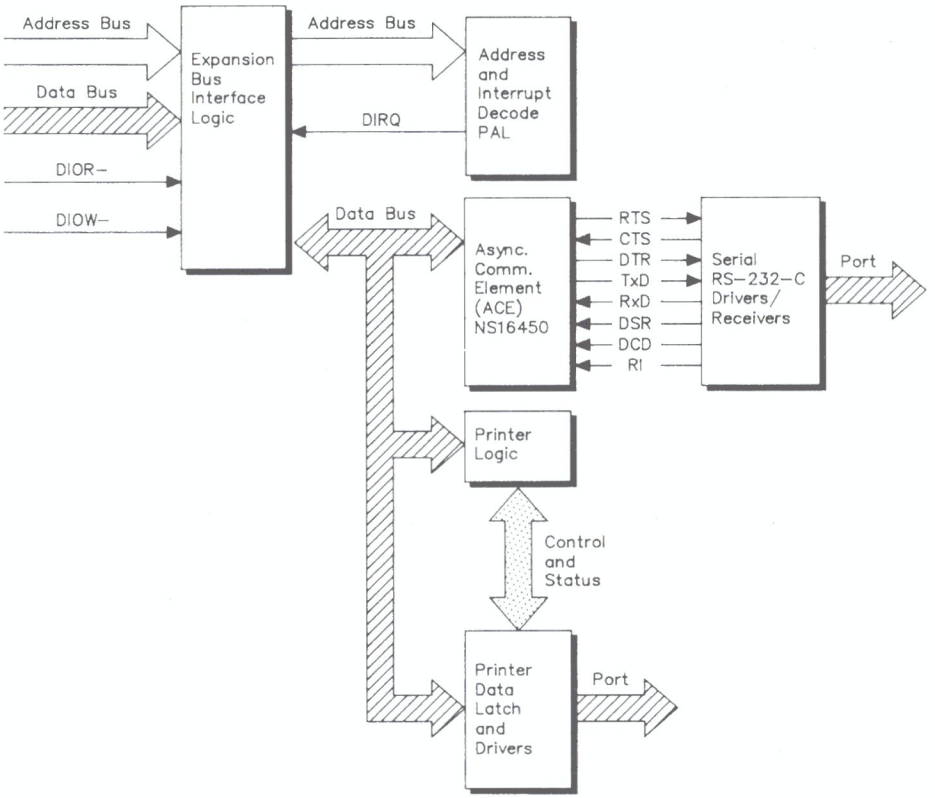


Figure B-2. Asynchronous Communications/Parallel Printer Board Functional Block Diagram

Table B-1. Asynchronous Communications/Parallel Printer Board I/O Ports

Port	R/W	Register Function	SW1 Switch Setting
278h	R/W	LPT3 Data	3=ON 4=OFF
279h	R	LPT3 Status	"
279h	W	LPT3 Reserved	"
27Ah	R/W	LPT3 Control	"
27Bh	R/W	LPT3 Reserved	"
2F8h	R/W	COM2 Divisor Latch LSB (with DLA bit = 1) (Note)	5=OFF 6=ON
2F8h	R	COM2 Received Data (with DLA bit = 0) (Note)	"
2F8h	W	COM2 Transmit Data (with DLA bit = 0) (Note)	"
2F9h	R/W	COM2 Divisor Latch MSB (with DLA bit = 1) (Note)	"
2F9h	R/W	COM2 Interrupt Enable (with DLA bit = 0) (Note)	"
2FAh	R	COM2 Interrupt ID	"
2FAh	W	COM2 Reserved	"
2FBh	R/W	COM2 Line Control	"
2FCh	R/W	COM2 Modem Control	"
2FDh	R	COM2 Line Status	"
2FEh	R	COM2 Modem Status	"
2FFh	R/W	COM2 Scratch	"
378h	R/W	LPT2 Data	3=OFF 4=ON
379h	R	LPT2 Status	"

(Continued)

Table B-1. (Continued)

Port	R/W	Register Function	SW1 Switch Setting
379h	W	LPT2 Reserved	3=OFF 4=ON
37Ah	R/W	LPT2 Control	"
37Bh	R/W	LPT2 Reserved	"
3BCh	R/W	LPT1 Data	3=ON 4=ON
3BDh	R	LPT1 Status	"
3BDh	W	LPT1 Reserved	"
3BEh	R/W	LPT1 Control	"
3BFh	R/W	LPT1 Reserved	"
3F8h	R/W	COM1 Divisor Latch LSB (with DLA bit = 1) (Note)	5=ON 6=ON
3F8h	R	COM1 Received Data (with DLA bit = 0) (Note)	"
3F8h	W	COM1 Transmit Data (with DLA bit = 0) (Note)	"
3F9h	R/W	COM1 Divisor Latch MSB (with DLA bit = 1) (Note)	"
3F9h	R/W	COM1 Interrupt Enable (with DLA bit = 0) (Note)	"
3FAh	R	COM1 Interrupt ID	"
3FAh	W	COM1 Reserved	"
3FBh	R/W	COM1 Line Control	"
3FCh	R/W	COM1 Modem Control	"
Port	R/W	Register Function	SW1 Switch Setting
3FDh	R	COM1 Line Status	5=ON 6=ON
3FEh	R	COM1 Modem Status	"
3FFh	R/W	COM1 Scratch	"

Note: The DLA bit is in the Line Control register. This bit must be set (=1) to access the divisor latches and reset (=0) to access the Data and the Interrupt Enable registers.

(Continued)

B.2 ASYNCHRONOUS SERIAL COMMUNICATIONS CIRCUITS

The core of the asynchronous serial communications circuit is a National Semiconductor NS16450 Element (ACE). This device changes data received in a parallel format from the system to a serial format for output to a serial device. It also performs the reverse function, changing data in serial format to parallel format.

The ACE is I/O-mapped at addresses 3F8h or 2F8h, depending on the selection of COM1 or COM2.

Table B-2 lists the ACE registers, which are described in the following paragraphs.

Table B-2. ACE Registers

Port		R/W	Register Function	
			Receiver Buffer or Transmitter Holding	
2F8h	2F9h	R/W	Baud Rate Divisor Latch	(COM2)
3F8h	3F9h	R/W	" " " "	(COM1)
2F9h		R/W	Interrupt Enable	(COM2)
3F9h		R/W	" "	(COM1)
1FAh		R	Interrupt ID	(COM2)
3FAh		R	" "	(COM1)
2FBh		R/W	Line Control	(COM2)
3FBh		R/W	" "	(COM1)
2FCh		R/W	Modem Control	(COM2)
3FCh		R/W	" "	(COM1)
2FDh		RO	Line Status	(COM2)
3FDh		RO	" "	(COM1)
2FEh		RO	Modem Status	(COM2)
3FEh		RO	" "	(COM1)
2FAh		W	Reserved	(COM2)
3FAh		W	"	(COM1)

ACE Receiver Buffer or Transmitter Holding

This register contains the byte just received or the next byte to be transmitted by the ACE.

ACE BAUD RATE DIVISOR LATCH

The ACE device contains a built-in baud rate generator that divides the input clock (1.8432 MHz) by a divisor to create a desired baud rate or serial transmission frequency. The divisor is found according to the equation:

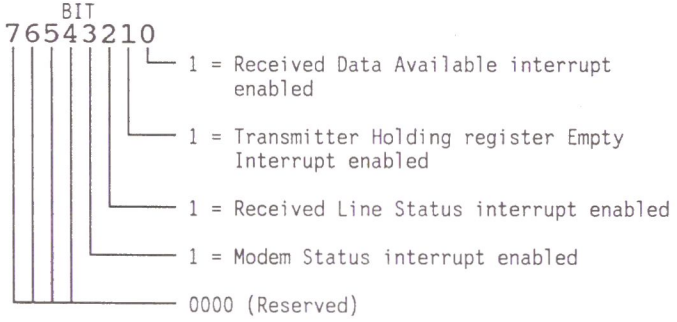
Divisor = 1843200/(Desired Baud Rate x 16)

Baud Rate	Divisor
110	1047
150	768
300	384
600	192
1200	96
2400	48
4800	24
9600	12

Setting bit <7> (=1) enables the first two I/O addresses of the Line Control register as the addresses for the least- and most-significant bytes of the 16-bit baud rate divisor.

ACE INTERRUPT ENABLE

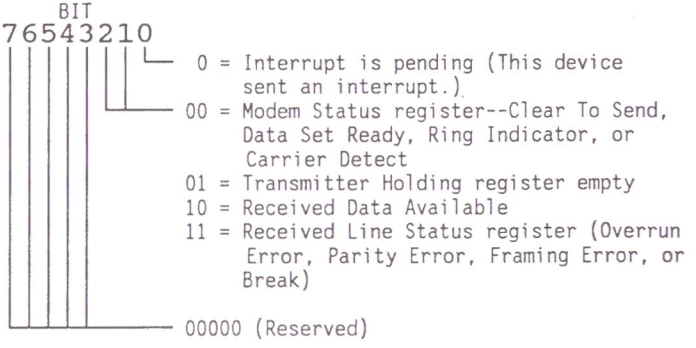
The bits of this register enable as many as four interrupt sources. The register format is as follows:


BIT
76543210
1 = Received Data Available interrupt enabled
1 = Transmitter Holding register Empty Interrupt enabled
1 = Received Line Status interrupt enabled
1 = Modem Status interrupt enabled
0000 (Reserved)

ACE INTERRUPT ID

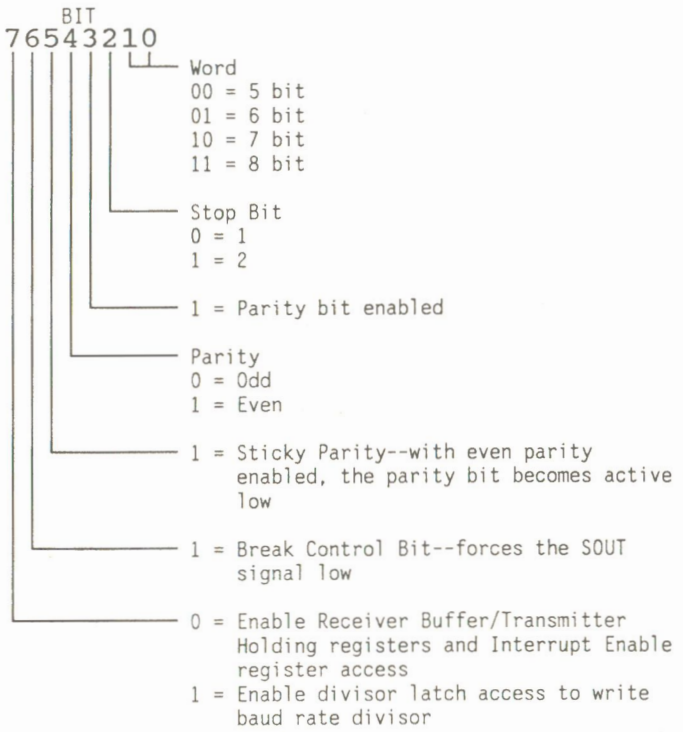
When a hardware interrupt occurs, the system searches for the device sending the interrupt and the reason for that interrupt.

This register contains 1 bit that flags the ACE as the source of the interrupt and 2 bits that specify the reason for the interrupt. The ACE interrupts are prioritized with the lowest-priority interrupt first. To clear the interrupt, read the contents of the register shown.


BIT
76543210
0 = Interrupt is pending (This device sent an interrupt.)
00 = Modem Status register--Clear To Send, Data Set Ready, Ring Indicator, or Carrier Detect
01 = Transmitter Holding register empty
10 = Received Data Available
11 = Received Line Status register (Overrun Error, Parity Error, Framing Error, or Break)
00000 (Reserved)

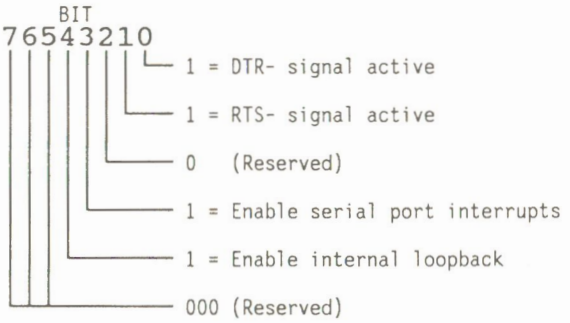
ACE Line Control

This register specifies the serial data transmission format.


BIT
76543210
Word
00 = 5 bit
01 = 6 bit
10 = 7 bit
11 = 8 bit
Stop Bit
0 = 1
1 = 2
1 = Parity bit enabled
Parity
0 = Odd
1 = Even
1 = Sticky Parity--with even parity enabled, the parity bit becomes active low
1 = Break Control Bit--forces the SOUT signal low
0 = Enable Receiver Buffer/Transmitter Holding registers and Interrupt Enable register access
1 = Enable divisor latch access to write baud rate divisor

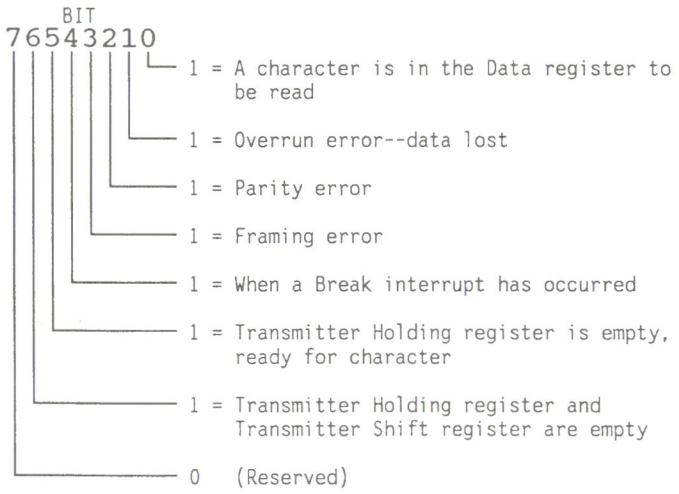
ACE MODEM CONTROL

This register controls the modem interface lines.



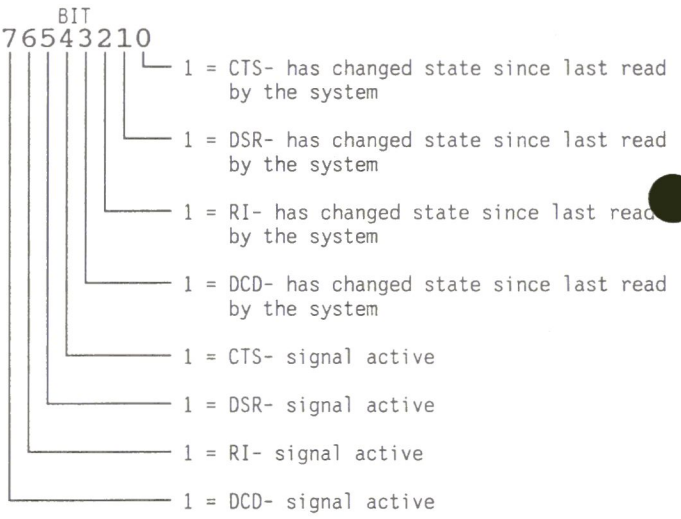
ACE LINE STATUS (READ ONLY)

This register contains the status of the current data transfer.


BIT
76543210
1 = A character is in the Data register to be read
1 = Overrun error--data lost
1 = Parity error
1 = Framing error
1 = When a Break interrupt has occurred
1 = Transmitter Holding register is empty, ready for character
1 = Transmitter Holding register and Transmitter Shift register are empty
0 (Reserved)

ACE MODEM STATUS (READ ONLY)

This register contains the status of the modem interface lines.


BIT
76543210
1 = CTS- has changed state since last read by the system
1 = DSR- has changed state since last read by the system
1 = RI- has changed state since last read by the system
1 = DCD- has changed state since last read by the system
1 = CTS- signal active
1 = DSR- signal active
1 = RI- signal active
1 = DCD- signal active

ACE RESERVED

This register is not used currently.

B.3 PARALLEL PRINTER CIRCUITS

One of three addressable printer ports can be selected by setting the positions of switches 3 and 4 in switch bank 1 (SW1). The printer port can also be disabled by these switches, which allows the use of a printer port of a different controller. (For a summary of switch settings, see Section B.5, Switches.)

The printer circuits are addressed as ports. Data are sent parallel to the printer, and printer status is received from the printer through these ports.

Before printing, the system must select the printer for output (via the Printer Control register). For each byte sent to the computer, the system:

1. Checks the Printer Status register. If the busy, paper out, or printer fault signals are active, the system either waits until the status changes or it shows an error message. (For a complete listing of the error messages, refer to Appendix A, Error Messages.)

2. Sends a byte of data to the Printer Data register, then pulses the printer STROBE signal (through the Printer Control register) for 500 ns (or longer).

3. Monitors the Printer Status register for acknowledgment of the data byte before sending the next byte.

In addition to DATA lines to the printer, the system also has several lines that control printer functions. Printer functions are controlled by writing to or reading from I/O ports.

Table B-3 lists the parallel printer registers and their I/O ports.

Table B-3. Parallel Printer Registers

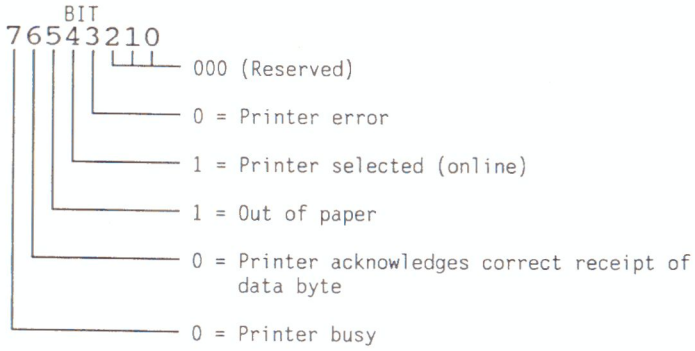
Port	R/W	Register Function	Device
278h	R/W	Printer Data	LPT3
378h	R/W		LPT2
3BCh	R/W		LPT1
279h	R	Printer Status	LPT3
379h	R		LPT2
3BDh	R		LPT1
27Ah	R/W	Printer Control	LPT3
37Ah	R/W		LPT2
3BEh	R/W		LPT1
279h	W	Printer Reserved	LPT3
27Bh	R/W		LPT3
379h	W		LPT2
37Bh	R/W		LPT2
3BDh	W		LPT1
3BFh	R/W		LPT1

PRINTER DATA

Each byte written to the Printer Data register (read or write) is latched into a loopback register and is sent to the printer. The register contents can be read back (for test purposes).

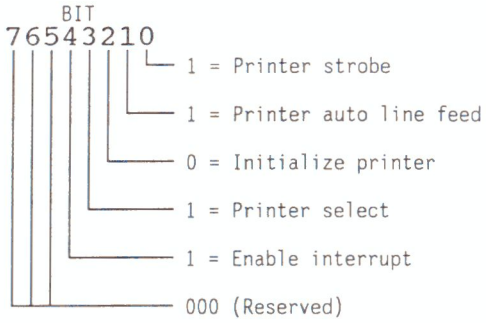
PRINTER STATUS (READ ONLY)

This register contains the current printer status.



PRINTER CONTROL

This register selects the printer for output, strobes the data into the printer, and performs other printer control functions.



B.4 SWITCHES

Table B-4 list the Asynchronous Communications/Parallel Printer Board switch settings.

Table B-4. Asynchronous Communications/Parallel Printer Board Switch Settings

Number	Function
5,6	Serial Port Select: 5 = ON 6 = ON -- COM1 Selected 5 = OFF 6 = ON -- COM2 Selected 5 = ON 6 = OFF -- Invalid 5 = OFF 6 = OFF -- Invalid
3,4	Printer Port Select: 3 = ON 4 = ON -- LPT1 Selected 3 = OFF 4 = ON -- LPT2 Selected 3 = ON 4 = OFF -- LPT3 Selected 3 = OFF 4 = OFF -- LPT Disabled
2	Serial Port Disable: 2 = ON -- Enabled 2 = OFF -- Disabled
1	Reserved Always OFF

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